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MACKENZIE RIVER WATER LEVELS AND THE FLOODING OF DELTA LAKES

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TABLE OF CONTENTS

	Page
ABSTRACT	ii
1. INTRODUCTION	1
2. STUDY AREA AND DATA SOURCES	3
2.1 Water levels	3
2.2 Lake sill elevation	7
3. MACKENZIE RIVER REGIME, SILL ELEVATIONS, AND LAKE FLOODING	8
4. METHODOLOGY	12
4.1 Analysis of spring and summer water levels	15
4.2 Partial duration series analysis of spring high water levels	16
Timing	19
Magnitude	20
Duration	21
Goodness-of-fit of selected stochastic models	22
5. LAKE SILL ELEVATIONS	23
6. ANALYSIS OF SPRING AND SUMMER WATER LEVELS	29
6.1 Timing	29
6.2 Extreme levels	34
6.3 Number and duration of events	38
6.4 Inflow events	41
6.5 Study lakes	43
7. PARTIAL DURATION SERIES ANALYSIS OF SPRING HIGH WATER LEVELS	45
7.1 Stationarity	46
7.2 Timing	48
7.3 Magnitude	50
7.4 Duration	53
8. CONCLUSIONS	55
REFERENCES	57
APPENDICES	

ABSTRACT

The hydrologic regime of lakes in the Mackenzie Delta is controlled primarily by lake sill elevations and water levels in the Mackenzie River distributing channels. The resulting variations in lake regime have important effects on the water, sediment, and nutrient balance of delta lakes, and therefore on the biologic regime of each lake.

Analysis of 12 to 25 years of Mackenzie River East Channel water levels allowed the documentation of the relationship between flooding regime and sill elevation for lakes in the study area near Inuvik, N.W.T. These data showed that in this portion of the delta, the timing of the spring rise in water levels is very consistent, with peak levels, for example, occurring on June 3 with a standard deviation of only 4 days. The magnitude of the spring flood varies greatly from year to year, and as a result only 67% of lakes in the study area flood annually in the spring, while the remaining lakes have a flood frequency of greater than 1 year and less than 4 years. Since the mean summer flood peak of 2.777 m asl is considerably lower than the mean spring peak of 5.636 m asl, summer lake flooding is not as extensive, with only 20% of lakes receiving floodwater annually during the summer. By late summer, water levels drop to 1.5 m asl annually, cutting off approximately 88% of lakes from the Mackenzie River.

Variations in the hydrologic regime of the Mackenzie River could occur in the future due to hydro-electric development, climate change, or rising sea level. Even small changes in Mackenzie River levels could result in a significant modification to the hydrologic regime of delta lakes. The effects on the viability of these lakes or their chemical and nutrient balances are not well known.

1. INTRODUCTION

The Mackenzie Delta is the largest delta in Canada and one of the major northern deltas in the world, second only in size to the Lena (Coleman, 1976). A unique feature of northern deltas is the occurrence of permafrost, which limits subsurface drainage and influences erosion within the delta plain. In conjunction with the permafrost, climatic and hydrologic conditions combine to create a large number of freshwater lakes, which cover up to 50% of the Mackenzie deltaic plain. In this respect the Mackenzie Delta is very different from most deltas, where interlevee lakes are not as common (Coleman et al., 1986).

Even though the Mackenzie River enters the Beaufort Sea at about 69° N (Figure 1), the Delta in general and the delta lakes in particular are productive ecosystems (Gill, 1971; Peterson, et al., 1981). The richness of these habitats is due primarily to their periodic flooding by the Mackenzie River, which introduces water, sediment, energy, chemicals, and nutrients to them. Since delta lakes occur over a range of elevations relative to the river, they experience very different flooding regimes, and therefore are very different physically and biologically.

Marsh (1986a,b) has demonstrated that flooding by the Mackenzie River dominates the water balance of delta lakes. In order to understand the hydrology of lakes in the Mackenzie Delta it is essential to understand the frequency, timing, and duration of flooding events. In this study, an analysis of Mackenzie River water levels will be used to determine the flooding regime of lakes near Inuvik. This report represents an initial analysis of the data, and provides a detailed listing of the data in the accompanying appendices.

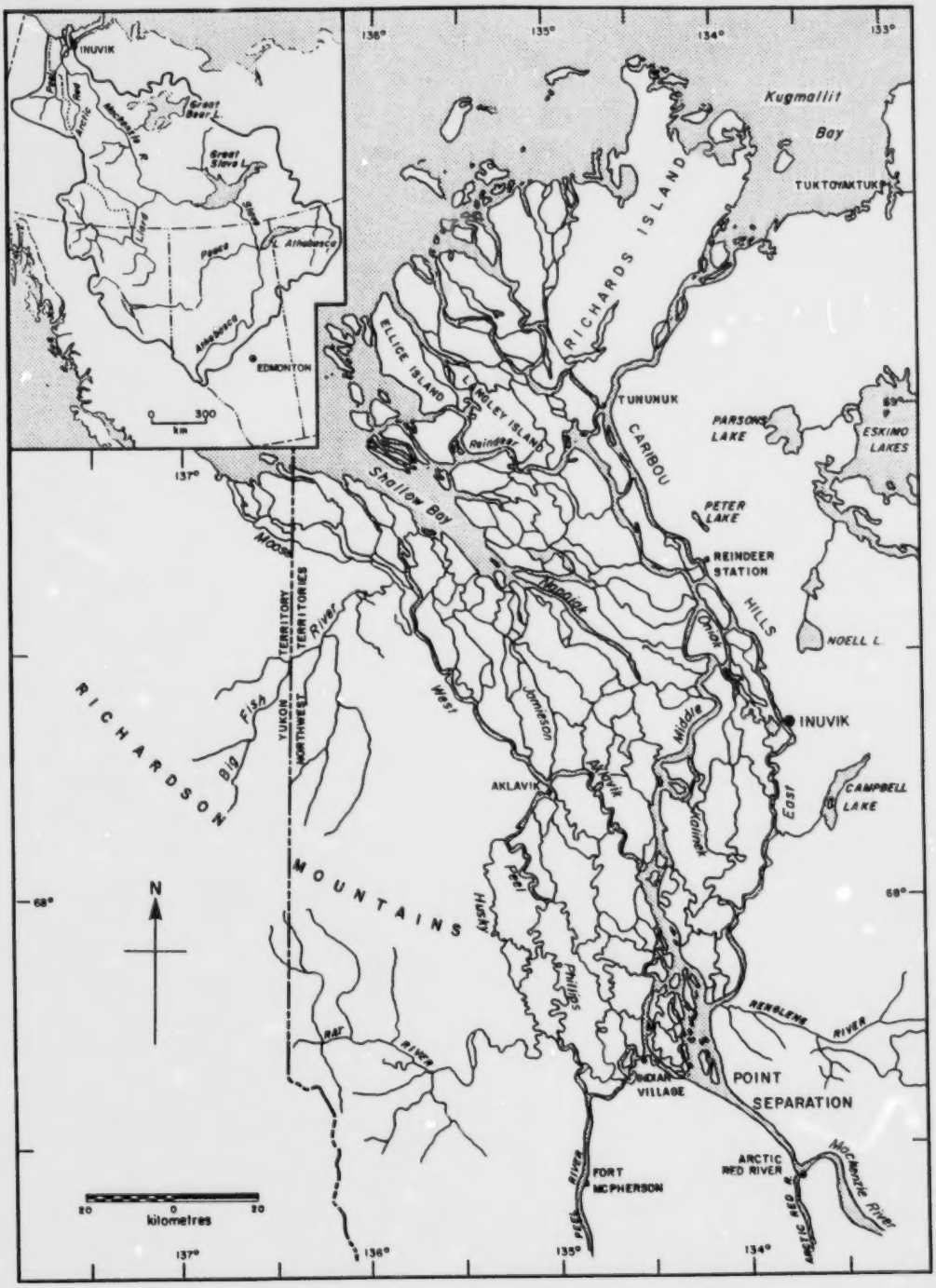


Fig. 1 Mackenzie Delta and Mackenzie River drainage basin.

2. STUDY AREA AND DATA SOURCES

2.1 Water levels

A number of earlier studies (B.C. Hydro, 1985; Hirst et al., 1987) have relied on main channel discharge to describe the hydrology of the delta. However, since flooding of a given lake by the Mackenzie River is dependent on water levels in nearby channels, water level is more important to the lake environment than main channel discharge. The importance of water levels and not discharge in this delta environment is often not recognized. In addition, as shown in Figure 2, there is a poor relationship between peak water level and discharge during the spring break-up period. This problem is related to difficulties in measuring discharge during the spring break-up due to ice in the main channels. Water levels, however, may be easily and accurately measured throughout the spring and summer period. For these reasons, water level will be used exclusively in the present study.

Water levels have been measured at numerous channel and lake sites in the Mackenzie Delta (Environment Canada, 1987), but at most locations the data are available only for short or intermittent periods. The only gauging station with sufficient record for a statistical analysis is located on the Mackenzie River East Channel at Inuvik (Figure 3). East Channel is a major distributary channel and it plays an important role in controlling lake levels in the eastern section of the delta. Water levels in East Channel at Inuvik are

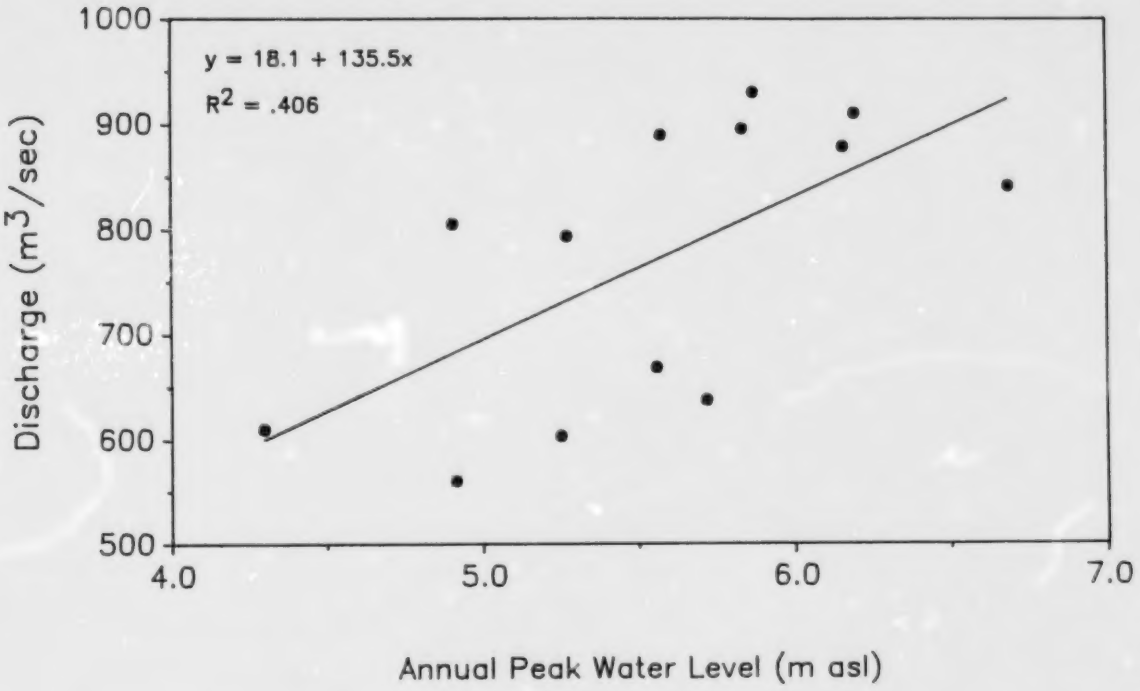


Fig. 2 Discharge versus annual peak daily water level, for WSC station at East Channel, Mackenzie River.

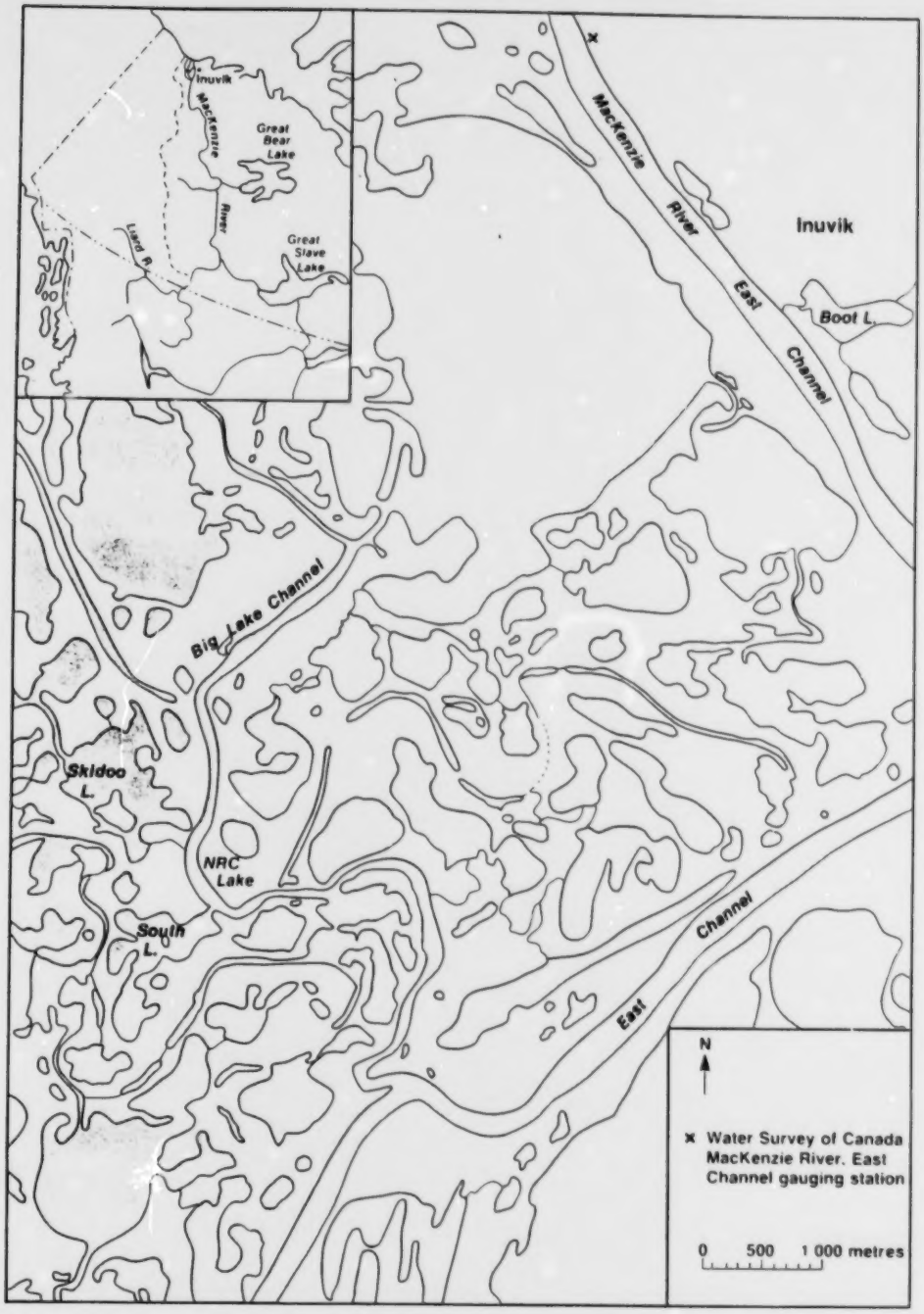


Fig. 3 Location of the study area, near Inuvik, N.W.T.

representative of those in the central eastern section of the delta. However, the data from Inuvik cannot be applied to other areas in the delta where water level regimes may be significantly different due to variations in levee heights (Mackay, 1963) and ice jamming. Instantaneous water levels during the spring flood period were measured at this site in 1954 by Brown (1957), and from 1964 to 1973 by the Inuvik Scientific Resource Center (Ostrick, 1987). Continuous measurements of water level and discharge have been carried out by the Water Survey of Canada from 1974 to the present (Environment Canada, 1987). Mean daily water level measurements from this site will be used in the present study to illustrate the flooding history of nearby lakes. In addition, lake levels for South Lake, Skidoo Lake, and NRC Lake (Figure 3, note that these are unofficial place names) are available for 1983 to 1986. These lakes are approximately 5 km southwest of Inuvik and allow a comparison of lake and channel levels. Water levels discussed in this report are instantaneous values for the period 1954 and 1964 to 1973, and are mean daily values for 1974 to 1986.

Water levels reported by WSC are referenced to a bench mark (IWD8) established on East Channel by McElhanney (1983). This bench mark, surveyed using Doppler and inertial techniques, is referenced to mean sea level and has a reported accuracy of $\pm$0.53 m at the 95% confidence level (McElhanney, 1983). The water levels reported for East Channel as measured by Brown (1957), the Inuvik Scientific Resource Centre, and for the study lakes, are also referenced to this bench mark.

Previous studies (Brown, 1957; Mackay, 1963; Pearce, 1986) have used either the fall or winter low water level as a reference point for water levels in the delta. This type of datum has the disadvantage that the low water level is not well-defined and varies from year to year. The principal advantages, however, are that a surveyed bench mark is not required and the results can easily be applied elsewhere in the delta without resorting to expensive surveys. In this study the winter low water level at the WSC gauging site is defined as the mean water level on May 1. In order to use this reference point, the mean May 1 water level (1.465 m asl) must be subtracted from all water levels used in this report.

2.2 Lake sill elevation

Variations in main channel water level play an important role in the hydrology of the delta lakes. Water may move between the main channels and the lakes when the main channel water level is above the sill separating the lake and the main channel. The lake sill is defined as (1) the highest elevation along the channel thalweg connecting the lake to a main channel or (2) if there is no channel connecting the lake, then the lowest elevation in the levee between the lake and channel. During the spring, sill levels are effectively increased by snow and ice which block the lake channels.

Lake sill elevation was measured using both ground and aerial survey techniques. The small, shallow channels and thick underbrush typical of this part of the delta make ground surveying difficult, and as a result only 14

lakes were measured. The number of lakes sampled was increased by conducting an aerial survey of lake flooding. As the main channel water level rises during the spring period, it sequentially overtops lake sills and water floods into increasingly higher elevation lakes. An observation of the first date of flooding, in conjunction with a measurement of main channel water level, allows a determination of the lake sill elevation. Since the Mackenzie River water is heavily sediment laden, it is easy to distinguish flood water from local meltwater. Using this method, the sill elevations of 132 lakes, totalling 32 km^2 in area, were determined (Appendix D1).

3. MACKENZIE RIVER REGIME, SILL ELEVATIONS, AND LAKE FLOODING

In the Mackenzie Delta, water levels in the main channels increase slowly throughout winter (Figure 4, Appendix A3). During early May, however, levels increase dramatically from their late winter lows in response to meltwater arriving from southern sections of the basin as the floodwave propagates northward. The primary source of this water is the Mackenzie River which contributes approximately 90% of the total flow entering the delta. The Peel River, which supplies 8% of the total flow, influences the magnitude and timing of spring water levels in the western portion of the delta. Water levels continue to rise throughout May in response to this input of water, peaking in late May to early June (Figure 4, Appendix A3). In the Inuvik area (Figures 1 and 3), peak levels are typically between 4 and 7 m asl, or 2.5 to 5.5 m above low winter levels (Figure 4, Appendix A3). These high water levels are related to both high discharge due to snow-melt in the southern portions of the basin and the occurrence of ice jams in the Mackenzie Delta.

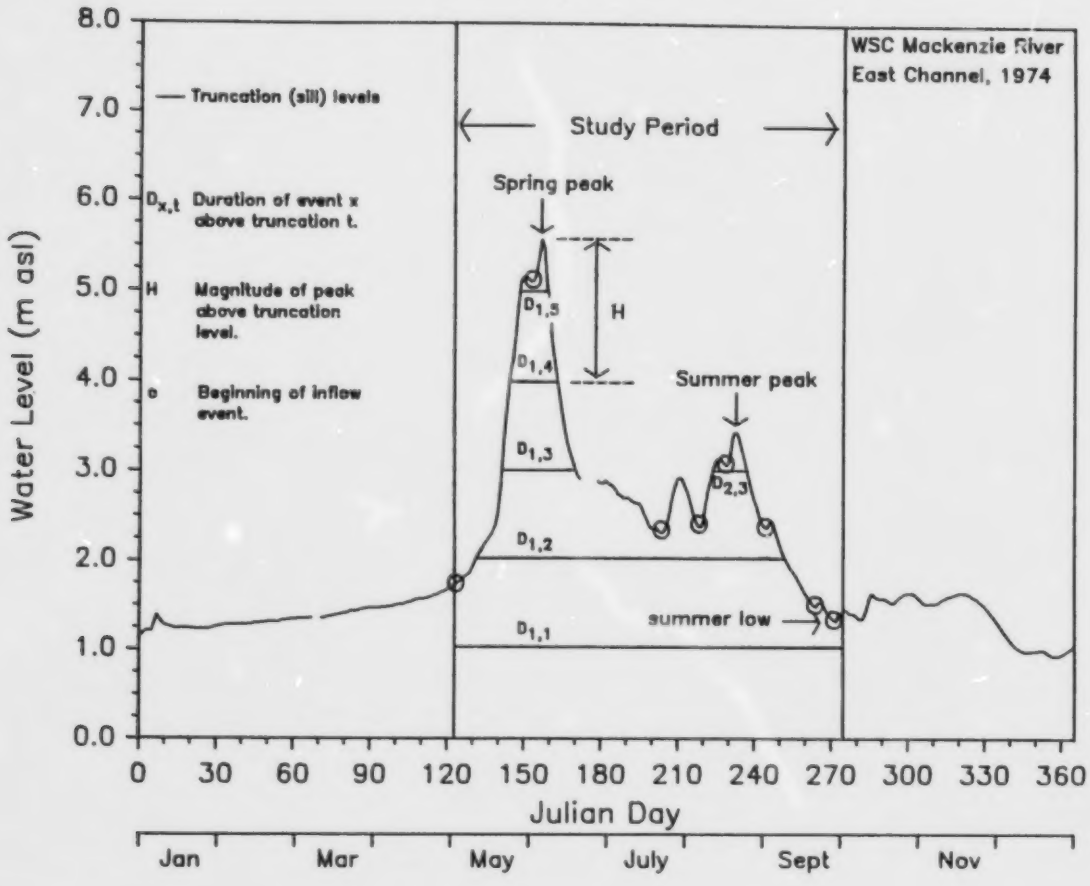


Fig. 4 Illustration of truncation levels and parameters used in the paper.

At the end of winter the main channel ice cover is substantial, varying from 0.9 m to 1.6 m in thickness (Sherstone et al., 1986). The combination of melt from the surface and subsurface of the channel ice in response to increasing air temperatures (Figure 5a) and water temperatures (Prowse and Marsh, 1987), results in the removal of ice from the channels during this period of peak water levels (Figure 5b).

After the spring peak, water levels in the main channels drop rapidly (Figure 4), followed by a long period of gradually declining levels, with rain-induced peaks superimposed upon the flow regime. This water level pattern continues until after freeze-up in late September or early October. By January, the water level regime has changed considerably, with little variation in level. When the main channel levels are above the lake sills, the lake and channel levels are similar (Figure 5b). During this period, water flows into the lakes during periods of rising channel levels, and out of the lakes during periods of falling stage. A typical relationship between channel level and discharge into and out of a lake is shown in Figure 6 for South Lake. This discharge into and out of the lakes dominates the lake water balance (Marsh, 1986a).

Since air temperatures in the delta are below freezing in early May (Figure 5a), the initial rise in lake levels is not due to local melt, but is due entirely to flooding by the Mackenzie River. In fact, due to high soil infiltration rates, snow-melt run-off from the surrounding land to the lakes is often negligible (Marsh, 1987).

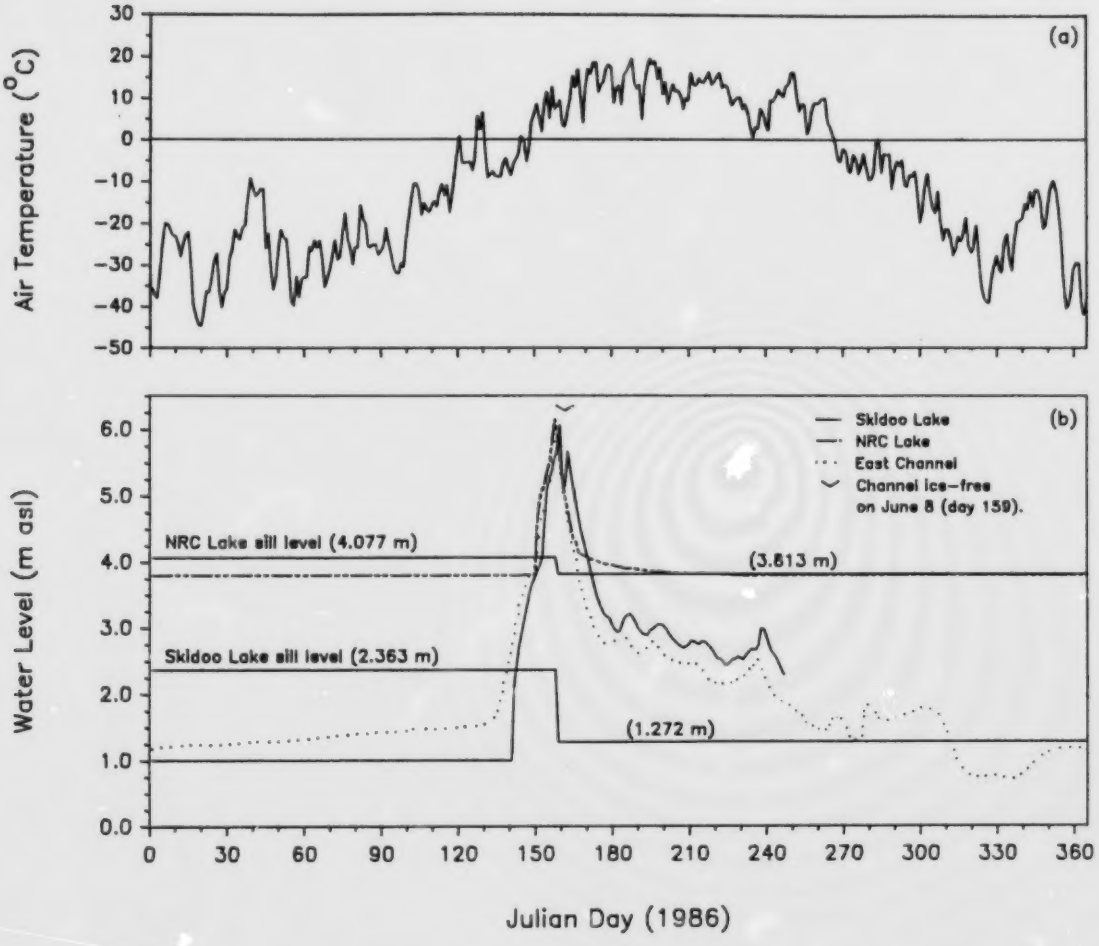


Fig. 5 (a) Mean daily air temperature at Atmospheric Environment Service, Inuvik, 1986.

(b) Annual hydrographs for East Channel, Skidoo Lake, NRC Lake, 1986.

Numerous studies (Mackay, 1963; Gill, 1971; B.C. Hydro, 1985; Marsh, 1986b; Hirst et al., 1987; Bigras, 1987; Lewis, in prep.) have recognized the difference between high and low elevation lakes and have proposed simple classification schemes (Table 1). In general, these studies recognize lakes with no closure, low closure, and high closure, where closure represents the elevation of the connection between the main channel and the lake.

In spite of the obvious utility of this classification scheme, few studies have quantified the hydrologic regime of each lake type, determined the closure elevation for each lake type, or provided the percentage of lakes which fall into each class. Marsh and Hey (1988) quantified this lake classification scheme using data on the flooding frequency and lake elevation near Inuvik.

4. METHODOLOGY

The usefulness of analysing extreme discharge events in relation to critical discharge levels has been demonstrated previously (Todorovic, 1978). These critical levels often are referred to as truncation levels. Using this technique, flooding statistics such as timing, duration and magnitude are determined only for water levels above specific truncation levels. The use of truncation levels is not limited to analysis of discharge events, but may also be used to analyse water levels, either for the general description of water level regimes or for

Table 1. Description of Mackenzie Delta lake types.

Study	Lake Type	Description of Lake Type
Mackay(1963)	High closure	Flood infrequently.
	Low closure	Flood annually.
	No closure	Open lakes with channel flow.
Gill(1971)	High closure	Do not flood annually.
	Low closure	Flood annually.
	Channel-connected	Open lakes with channel flow; connected to active distributary.
Cordes and McLennan (1984)	Type C	Closed lake, flooded only during highest flood years.
	Type B	Closed lake, flooded annually.
	Type A	Connected lake, water levels continuous with channel all year.
B.C. Hydro(1985)	High closure	Floods infrequently or less than annually.
	Low closure	Floods annually, but loses connection during open water season.
	No closure	Connected to distributary for entire open water season.
Hirst et al.(1987)	Same as B.C. Hydro	
Bigras(1987)	Unconnected or perched	Not flooded annually, exclusive to southern portion of delta.
	High or low closure	Intermittently connected to channel during high water.
	Connected lakes	Connected by channel.
Marsh(1986a)	Perched	Defined two extremes and noted that there is a continuum between them.
	Channel-connected	
Lewis(in prep.) (See B.C. Hydro 1985, pp. 5-22 for discussion).	Closure	Distinguished on basis of lake size.
	No closure	

partial duration probability analysis of extreme events. This method has potential for analysing the flooding of river floodplains and the periodic inundation of floodplain lakes, delta lakes, marshes, or man-made features. Knowledge of the magnitude, timing, duration, and number of flooding events is of economic importance for man-made features and has implications for understanding the water, sediment, chemical, and nutrient budgets of floodplain lakes and wetlands.

In this report, East Channel water levels will be analysed in relation to truncation levels, in order to describe the hydrologic regime of Mackenzie Delta lakes. As discussed earlier, delta lakes occur at a variety of elevations in relation to the Mackenzie River, and therefore selected truncations can represent lake sill elevations. For example, the flooding history of a lake with a sill elevation of 4 m asl can be determined by analysing water levels using a truncation level of 4 m asl. This will provide information on flow variables only when the river level is above the lake sill elevation; i.e. the only time when the lake will be influenced by channel levels. The use of truncation levels in this study is shown in Figure 4. Water levels were analysed over the period May 1 to September 30 when the delta is most active hydrologically (Figure 4). This period encompasses the initial rise of water level and flooding of delta lakes, the spring peak, the summer period with fluctuating water levels, and the fall freeze-up. Only the winter period is not included. However, during much of the winter period the lake connecting channels are filled with ice and snow, preventing the movement of water between the main channels and most of the delta lakes.

The study period (May 1 to September 30) was broken into two periods, with the water levels during each dominated by different processes. The spring break-up period is dominated by snow-melt run-off and ice jamming, while during the summer period rainfall run-off is the major process. The spring period begins May 1, while the summer period was defined as starting when water levels increased for the first time after rapid recession from the spring peak. The initiation of the summer period therefore varies from year to year.

4.1 Analysis of spring and summer water levels

Water levels during the May 1 to September 30 period were analysed for:

(1) the time at which water levels rise above given truncation levels during the rapid spring rise in water level;

(2) the peak spring and summer levels;

(3) the number of times and the duration that water levels were above given truncations;

(4) the number of inflow events; and

(5) the summer minimum water level.

In each case the data were analysed for the mean, standard deviation, and minimum and maximum values.

The duration that channel water levels exceeded given truncations or sill levels was analysed for the first event of the year, for all subsequent events combined, and for all events combined. In general, the first event corresponds to the spring high water period and the subsequent events occur during the summer low water period. However, for low sill levels, the first event of the year extends well into the summer low water period (Figure 4).

Discharge into the delta lakes, here termed inflows, occurs whenever the main channel water level is rising (Figure 6). An inflow was recorded as such, regardless of the amount of reversal in water level or in the duration of the inflow before the next downtrend (outflow). This definition of an inflow event only applies to simple lake systems with a single channel connecting the lake to the main channel system.

The probabilities of extreme high and low flow events were determined using the annual series. This series often has been modelled with the Gumbel distribution (Yevjevich, 1972; Haan, 1977), which provides a suitable fit to the observed data when annual floods are produced by a single hydrologic process (Woo and Waylen, 1984). The theoretical basis for the application of the Gumbel distribution to peak levels has been examined previously (Todorovic, 1978), and it is used here to represent the peak level of the annual spring flood, the peak level occurring during the summer period, and the summer extreme low level. The cumulative form of the Gumbel for extreme maximum levels is given by

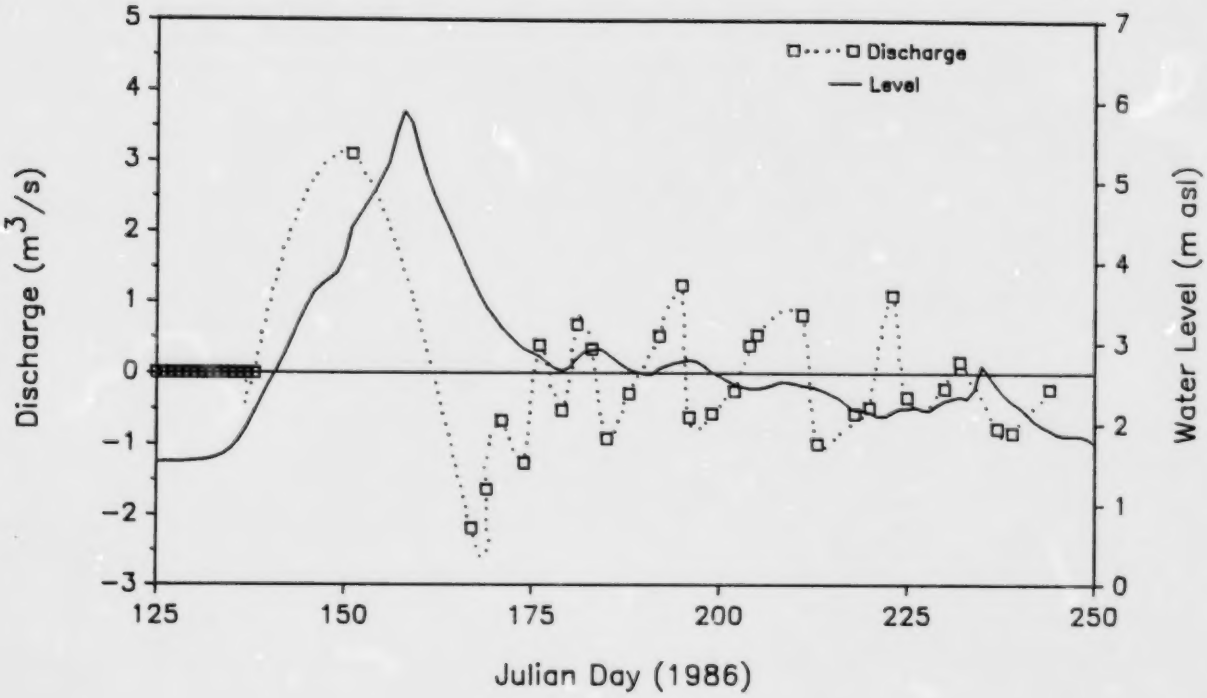


Fig. 6 Channel water level and lake channel discharge versus date, 1986, for South Lake.

(1) $P(L' >= L_t) = 1 - \exp[-\exp(-(L_t-\beta)/\alpha)]$

where $P(L' >= L_t)$ is the probability that the extreme maximum water level (L') is greater than or equal to the truncation level (L_t), $\alpha = \sigma/1.283$, $\beta = \mu-0.45\sigma$ (Haan, 1977), and μ and σ are respectively the mean and standard deviation of the recorded peak levels. For extreme minimum values

(2) $P(L_, <= L_t) = 1 - \exp[-\exp((L_t-\beta)/\alpha)]$

where $P(L_, <= L_t)$ is the probability that the extreme minimum water level ($L_,$) is less than or equal to the truncation level (L_t), $\alpha = \sigma/1.283$, $\beta = \mu+.45\sigma$, and μ and σ are respectively the mean and standard deviation of the recorded minimum levels.

4.2 Partial duration series analysis of spring high water levels

Recent studies have shown the effectiveness of partial duration series (PDS) analysis for modelling high flow events (Todorovic, 1978; Waylen and Woo, 1983). This technique has the advantage of allowing a probability analysis of magnitude, duration, timing, and number of high flow events, in relation to selected truncation levels. Theoretical support for the application of specific probability distributions (normal and exponential) to PDS variables has been provided previously (Cramer and Leadbetter, 1967; Todorovic, 1978). In order to use the PDS technique, the following criteria must be met. First, the high flow event must be independent. Second, it must be generated by a

single hydrologic process, precluding the need to consider multiple or compound processes. Third, since the analysis assumes stationarity in the data set, the parameters of the distributions used must be unchanging over time. In the current study, the PDS analysis is applied only to the spring break-up period in the Mackenzie Delta when water levels are above 4 m asl. This limits the analysis to a maximum of 1 event per year, and assures that conditions one and two are met. The stationarity of the time series will be analyzed in section 7.1.

Timing

For floods generated by single processes and which cluster at certain times of the year, the PDS technique may be used to determine the probability of having an event by a given date. Previous work (Waylen and Woo, 1983) has shown that this can be accomplished by using a non-homogeneous Poisson process to determine the probability of having 0,1,2... events up to day t.

For spring high flow events in the Mackenzie Delta, however, a slightly different approach may be taken since for flows greater than 4.0 m asl, a maximum of 1 flood per year has been observed. The annual number of flood events is therefore either 0 or 1, with a mean number of events per year (E) calculated as

(3) $E = K/N$

where K is the number of events in N years of record. For phenomena which do not occur uniformly throughout the year, the number of events is a function of time. This variation can be expressed as:

(4) $E(t) = K(t)/N$

where E(t) is the mean number of events up to day t, and K(t) is the total number of events from time 0 up to day t observed in N years of record. As shown by Waylen and Woo (1983), E(t) can be approximated by

(5) $E(t) = P(T <= t)\ E$

where P(T <= t), the cumulative Gaussian probability distribution of the time the high flow event begins (T), before day t, is given by

(6) $$P(T <= t) = \int_{-\infty}^{T} \frac{1}{\sigma(2\pi)^{1/2}} \exp \frac{[-(t-\mu)^2]}{[2\sigma]^2}\, dt$$

where σ, σ^2, and μ are respectively the standard deviation, variance, and mean of the observed Julian dates of the time a high flow event begins.

Magnitude

The exponential distribution has been suggested as an applicable model of the probability of water levels rising to a given level above each

truncation (Taesombut and Yevjevich, 1978; Waylen and Woo, 1983) and is applied in this study in the form

$$(7) \quad P(H \geq h) = \exp(-h/\gamma_t)$$

interpreted as the probability that the peak level H above a selected truncation, will be greater than or equal to the same amount h (in metres). The parameter γ_t is greater than zero, and is estimated via the method of moments by the mean peak level above the selected truncation, as

$$(8) \quad \gamma_t = \sum_{i=i}^{K} (L'_i - L_t)/K_t$$

where L'_i is the peak level of high flow i above the selected truncation level L_t, and K_t is the number of high flows above that truncation during the period of record. As in the examination of durations, the annual event from which truncations are selected can be assumed to be independent (Waylen and Woo, 1983).

Duration

The duration of a high flow event is the time between the upcrossing and the next downcrossing of a given truncation level, during which the level was met or exceeded. It has been shown that the exponential distribution is a suitable model of the duration of high flows, if the truncation level is sufficiently high that the event(s) can be considered independent (Cramer and Leadbetter, 1967; Waylen and Woo, 1983). The exponential is given by

(9) $P(D \geq d) = \exp(-d/\theta)$

interpreted as the probability that the duration D of the high flow above a selected truncation is greater than or equal to some duration d (in days). θ is a parameter greater than zero, estimated using the method of moments by the mean duration of events above the selected truncation level (Waylen and Woo, 1983).

Goodness-of-fit of selected stochastic models

The Kolmogorov-Smirnov goodness-of-fit test (K-S) was selected to examine the fit of observed frequencies of the variable values against the frequencies predicted by the models. The test is considered to be more powerful than the chi-square for small samples (Lilliefors, 1967). Tables of modified critical values were used to check for significant differences, because the standard K-S tables apply to nonparametric tests, and are not valid for parametric tests where the values for the parameters of the distributions are calculated from the sample data (Crutcher, 1975; Lilliefors, 1967, 1969).

Observed frequencies were plotted using the Weibull plotting formula of m/n+1, where m is the rank and n is the number of years of record (Haan, 1977). Some of the variables had only a few years of observations at the higher truncations. Because the probability of committing type-II errors increases with small sample sizes (Crutcher, 1975; Haan, 1977), testing was carried out at the .80 confidence level to reduce this probability.

5. LAKE SILL ELEVATIONS

The sequence of lake flooding during the spring flood in 1986 is illustrated in Figure 7. On May 17 (day 137) only 1 lake was flooded, but it was the largest lake in the study area, covering 26% of the total lake area. Over the next 21 days, the main channel water level rose from 1.958 to 5.868 m, a total of 3.910 m, flooding all but 7 lakes covering only 5% of the total lake area. Combining the information on the channel water level with the date of flooding of individual lakes shows that spring lake sill elevations range from about 1.5 m asl up to nearly 6 m asl (Figure 8d), with a mean of 3.92 m asl and a standard deviation of 0.90 m. These data illustrate that delta lakes occur over a continuum of sill elevations, and that there is not a sudden break which marks the change from low to high closure lakes.

The histograms of the number of lakes and lake area show that there are a small number of large, low elevation lakes, and a large number of small, high elevation lakes (Figure 8). For example, approximately 20% of all lakes have spring sills less than 3.0 m asl, but they comprise 72% of the total lake area. The 20% of lakes with sills higher than 4.5 m asl cover only 6% of the lake area.

A comparison of the lake sill elevations determined from the spring aerial survey and the summer ground survey shows a good correlation between the two estimates (Figure 9a), but there are consistent differences. Typically, the

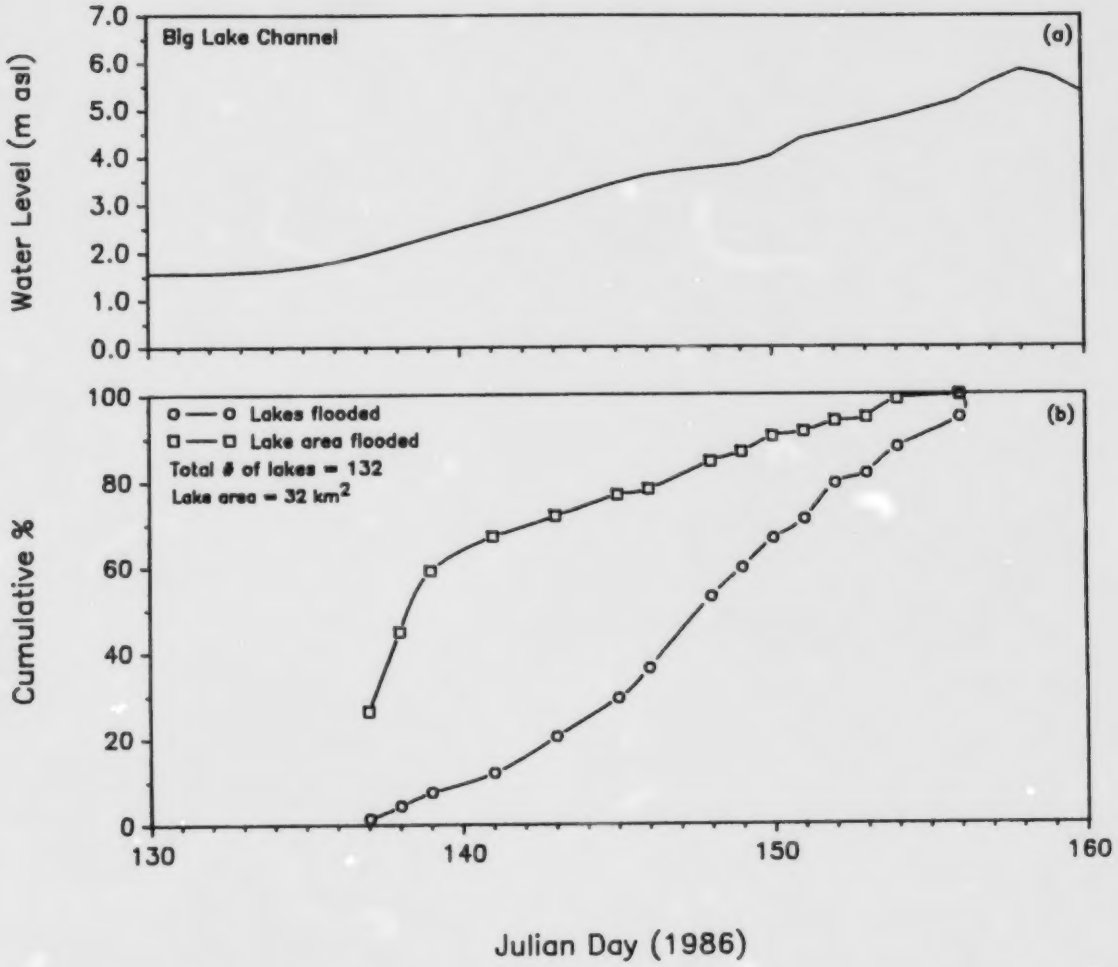


Fig. 7 Changes in channel water level and the cumulative percentage of number of lakes flooded and lake area flooded, 1986.

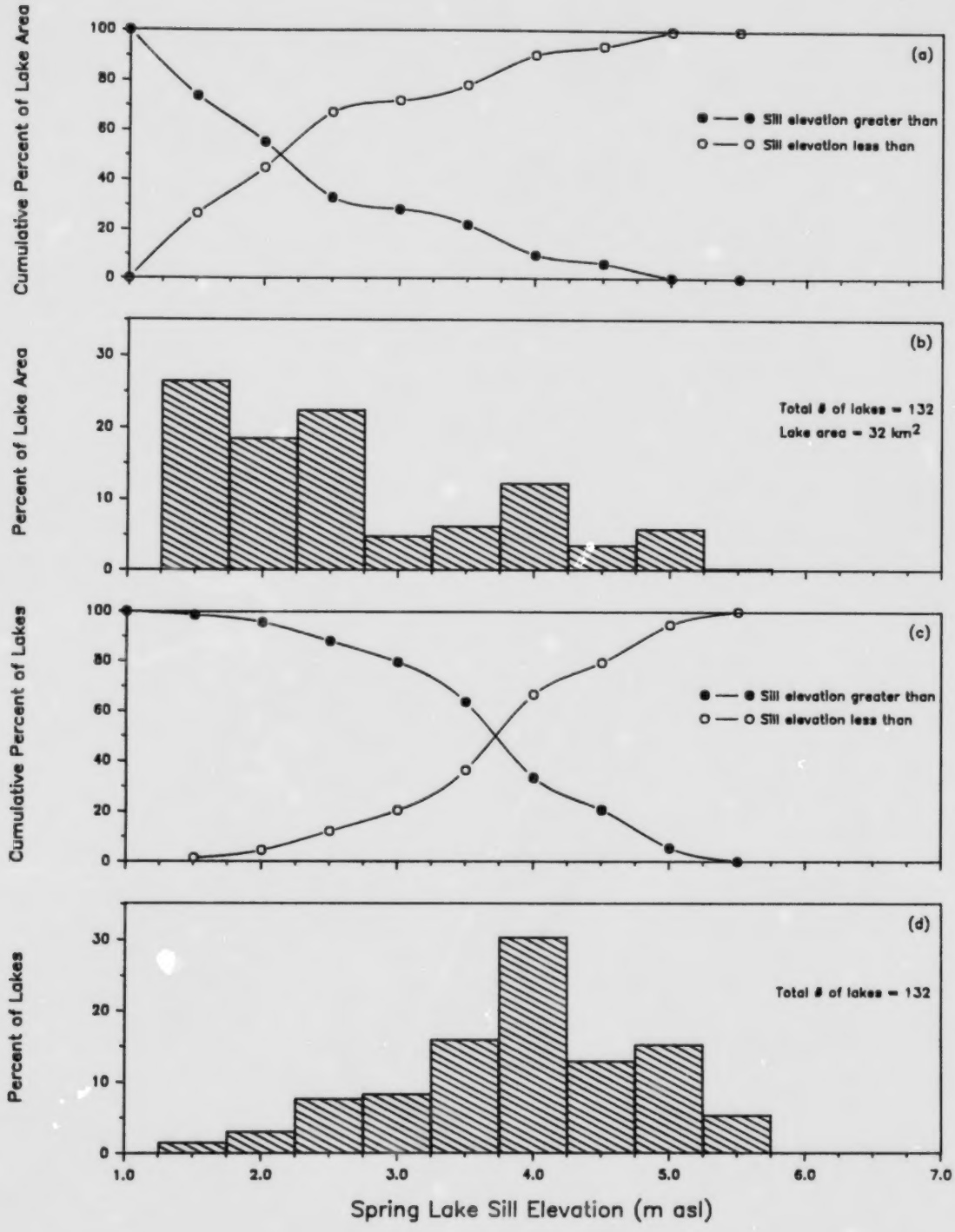


Fig. 8 Spring sill elevation versus percentage of lakes and lake area in study region.

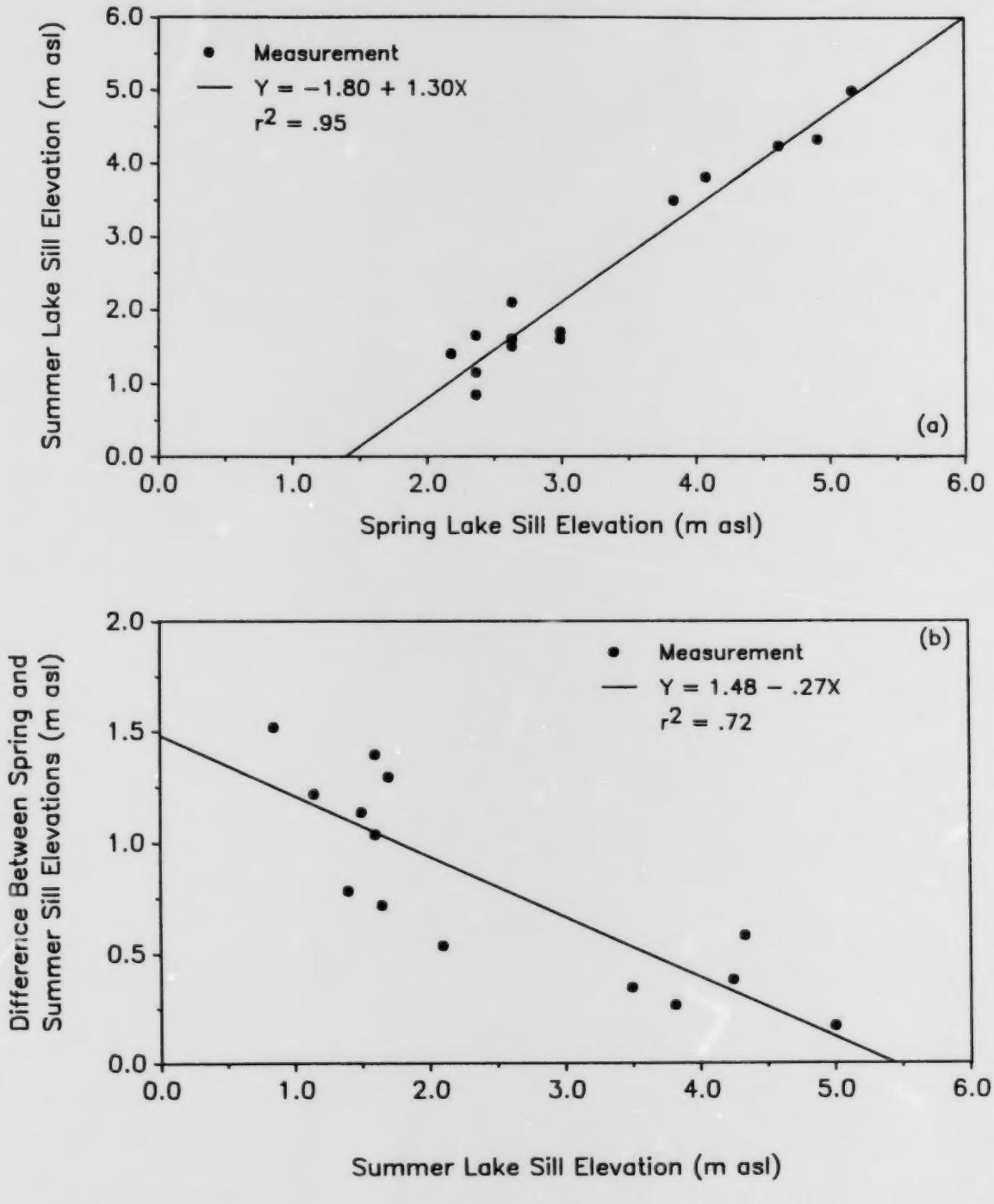


Fig. 9 Relationship between: (a) spring and summer sill elevation, and (b) summer sill elevation and difference between spring and summer sill elevation; for sample lakes.

summer sills were 0.25 to 1.50 m lower than when measured in the spring. This is due primarily to the blocking effect of snow and ice in the lake channels during the spring period. For example, a survey of Skidoo Channel in May 1987 (Figure 10), showed that the channel was frozen to the bed, and that the combination of snow and ice was approximately 1 m in thickness. This snow/ice dam effectively raises the lake sill elevation. Measurements taken in the spring of 1987 revealed that the channel water level was about 1 m higher than the lake summer sill elevation, but the lake had not yet been inundated. Figure 9b shows the relationship between summer sill elevation and the difference between the spring and summer sills. This difference is in effect a measurement of the thickness of the snow and ice dam. Low sill lakes have thicker snow/ice dams because they have deeper water in the connecting channels at freeze-up and therefore thicker ice covers in the spring. Typically the low level lakes have spring sills which are 1 to 1.5 m higher than the summer sill. Since the channels of the high sill lakes are dry at the beginning of winter, they are blocked only with snow. As a result, the difference between summer and spring sill elevation for high sill lakes is similar to the late spring snow cover, which is only 0.3 to 0.5 m in thickness.

Using the relationship between the spring and summer sill elevations (Figure 9a), the spring sill levels in Figure 8 can be adjusted to estimate the summer sill levels. Since it is impractical to measure summer sill levels for a large number of lakes from ground surveys, this estimation procedure is the only practical method to measure summer sill levels. The results are shown in

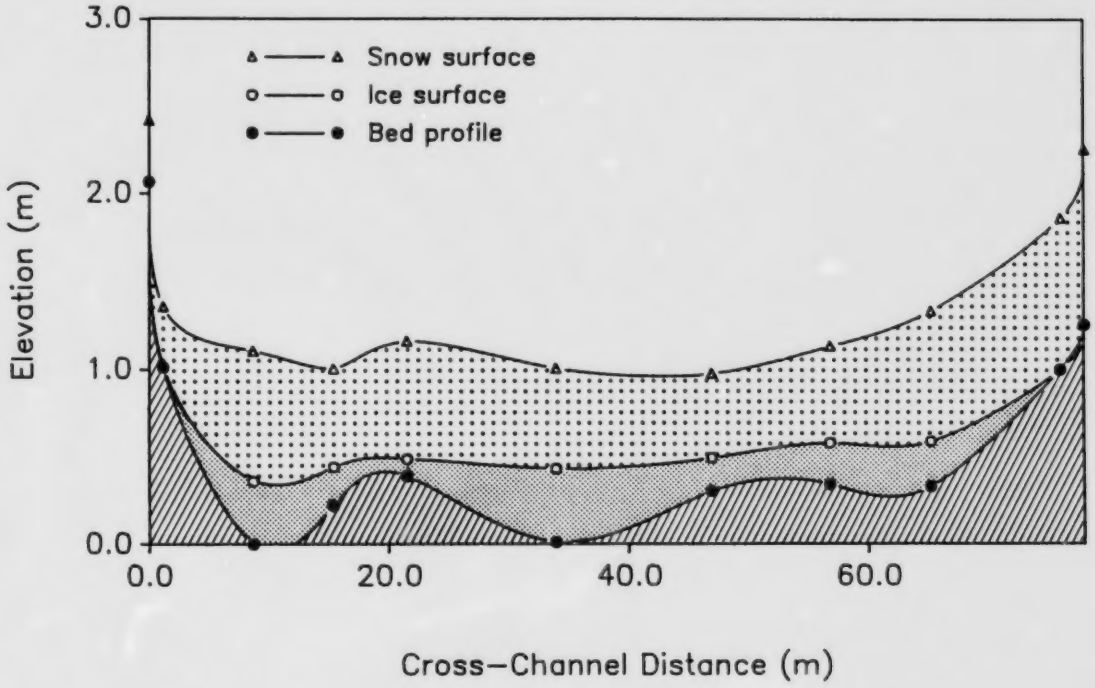


Fig. 10 Cross-section of snow and ice blockage, Skidoo Lake channel, 1987.

Figure 11 where the spring and summer sill elevations are compared, and in Figure 12 where the estimated percentage of lakes and lake area are shown for summer sill levels. The mean summer sill level is 3.24 m asl, approximately 0.68 m lower than the mean spring sill level.

6. ANALYSIS OF SPRING AND SUMMER WATER LEVELS

6.1 Timing

During early May, water levels rise slowly in the main channels, on average reaching 2 m asl on May 14 (day 134), 4 m on May 26 (day 146), and in years when the level reaches 6 m asl, it is attained by June 3 (day 154) (Figure 13, Table 2). The peak water level occurs on average on June 3, with the earliest recorded on May 28 (day 148) and the latest on June 9 (day 160). There is no relationship between the magnitude of the peak water level and its date of occurrence. These data demonstrate that virtually all lakes in the study area change from winter conditions, where they are either perched above the Mackenzie River or their connecting channels are dammed with snow and ice, to receiving flood water over a brief 20-day period in the latter part of May or early June.

The timing of this spring rise in water level and therefore the initial lake flooding is relatively consistent from year to year (Figure 13). The general pattern is for the standard deviation and the range between earliest and latest exceedance to decrease with higher water levels, with a standard

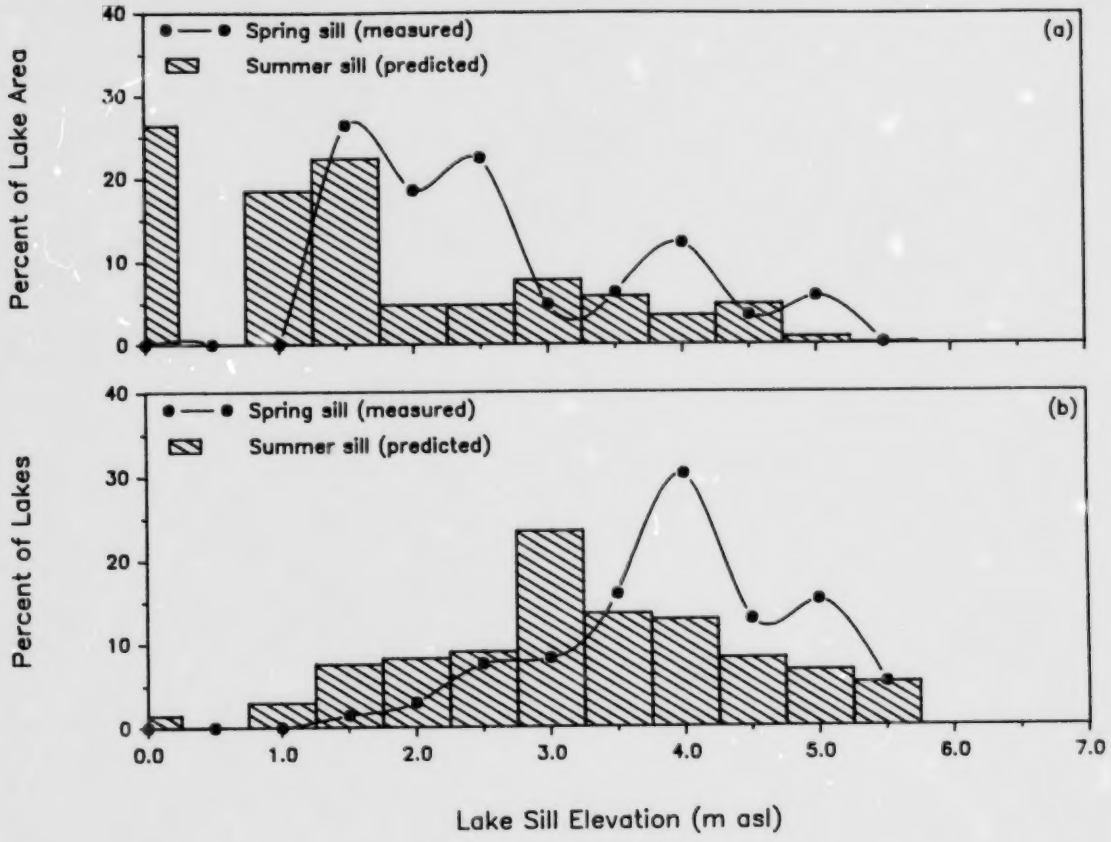


Fig. 11 Spring sills (measured) versus summer sills (predicted) from Figure 10a regression.

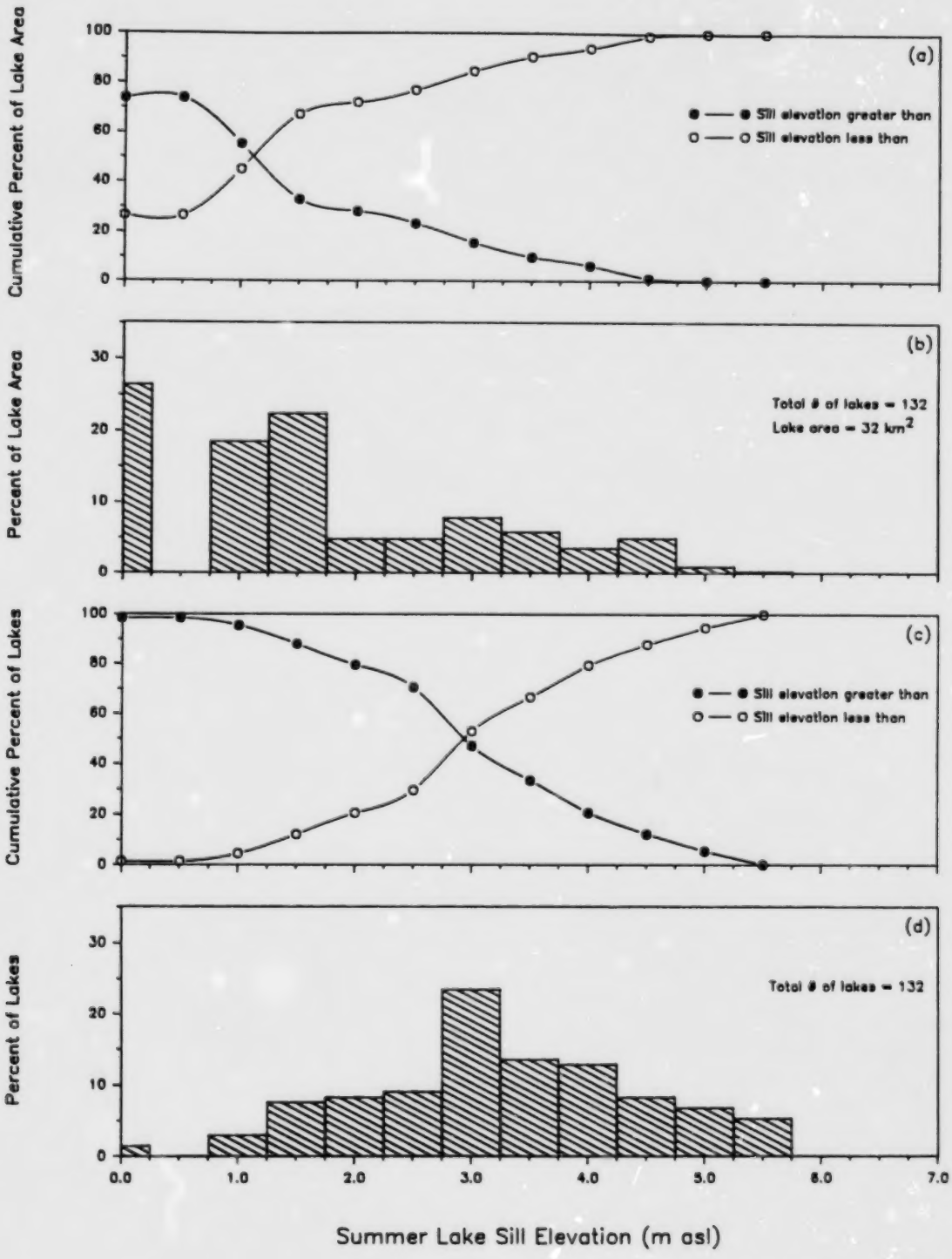

Cumulative Percent of Lake Area
(a)
● — ● Sill elevation greater than
○ — ○ Sill elevation less than
Percent of Lake Area
(b)
Total # of lakes = 132
Lake area = 32 km²
Cumulative Percent of Lakes
(c)
● — ● Sill elevation greater than
○ — ○ Sill elevation less than
Percent of Lakes
(d)
Total # of lakes = 132
Summer Lake Sill Elevation (m asl)

Fig. 12 Summer sill elevation versus percentage of lakes and lake area in study region.

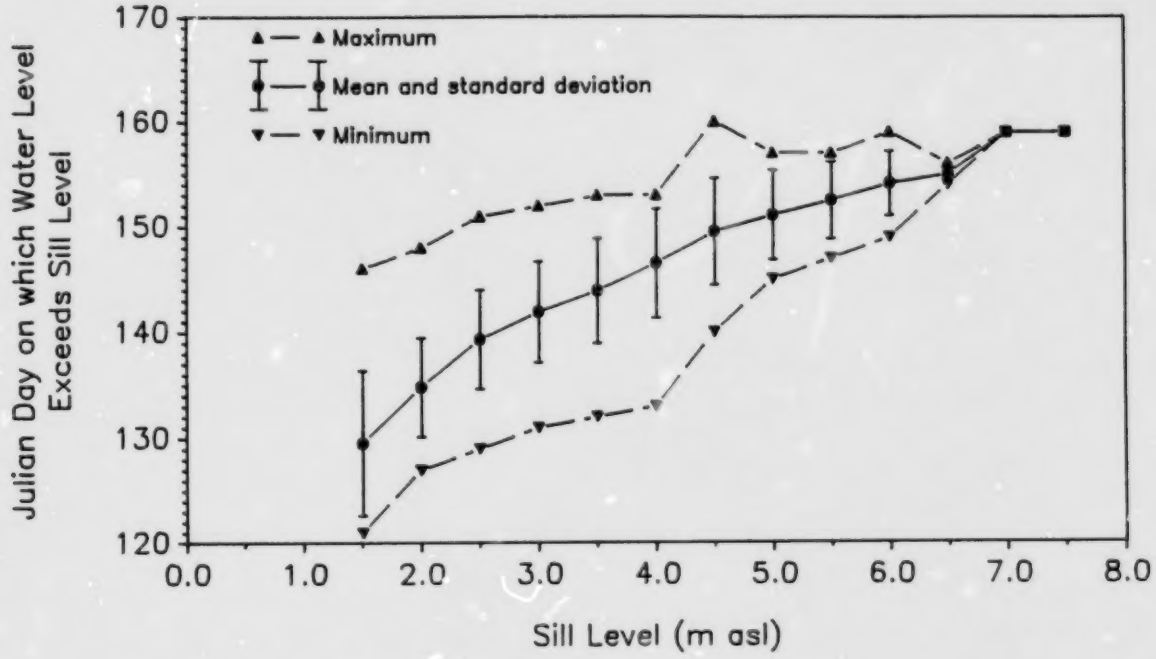


Fig. 13 Observed timing of water level exceeding sill level.

Table 2: Summary of flooding statistics for different sill elevations

(a) Spring sills

Sill level (m asl)	% of lakes	Mean date of spring flooding	Predicted ret. period of flooding(yrs)	Mean duration of first event (days/season)
1.0	0			151.3
1.5	1.5	129.5	1.0	120.6
2.0	3.0	134.8	1.0	74.8
2.5	7.6	139.3	1.0	48.5
3.0	8.3	141.9	1.0	26.3
3.5	15.9	143.9	1.0	19.4
4.0	30.3	146.5	1.0	14.1
4.5	12.9	149.5	1.0	9.3
5.0	15.2	151.1	1.2	5.5
5.5	5.3	152.5	2.0	2.7
6.0		154.1	3.8	0.9

(b) Summer sills

Sill level (m asl)	% of lakes	Predicted turn periods (yrs) max.	min.	Mean annual number of subseq. events	Duration of subseq. events (days/season)	Mean annual number of inflow events
0	1.5	1.0			0	
0.5	0	1.0			0	
1.0	3.0	1.0	11.4	0.15	1.5	14.3
1.5	7.6	1.0	1.0	1.75	7.8	12.0
2.0	8.3	1.0	1.0	1.09	6.4	6.5
2.5	9.1	1.4	1.0	0.55	5.1	3.5
3.0	23.5	4.1	1.0	0.33	2.8	1.9
3.5	13.6	17.5	1.0	0	0	0
4.0	12.9			0	0	0
4.5	8.3			0	0	0
5.0	6.8			0	0	0
5.5	5.3			0	0	0
6.0	0			0	0	0

Note: Data for the given sill levels are based on varying lengths of record, from 11 to 24 years.

deviation of the occurrence of the peak level of only 4.1 days. The consistency from year to year is due primarily to the large size of the Mackenzie basin (1,600,000 km^2). As a result, extreme events in one section of the basin are usually moderated by more normal conditions elsewhere.

6.2 Extreme levels

The plots of spring and summer peaks and summer lows on Gumbel extreme-value probability paper are generally linear (Figure 14), and the K-S test shows no significant difference between the observed and predicted frequencies at the .80 confidence level. As shown in Figure 14, the spring peak water level is the major hydrologic event of the year, ranging from 4.298 to 7.820 m asl, with a mean of 5.636 m asl. Combining these data with the information on lake sill levels shows that the mean annual peak water level would flood nearly all of the lakes in the study area.

The return period with which lakes are flooded in the spring varies greatly. For example, lakes with sill elevations of less than or equal to 4 m asl (67% of the total) flood annually, while the remaining 33% flood at less than annual intervals (Table 2). The highest lakes in the study area have sill elevations of between 5.5 and 6 m asl, and have flooding return periods of between 2 and 3 years. These lakes represent about 5% of those in the study area. During the highest spring water levels (Figure 14), all lakes in the study area are flooded.

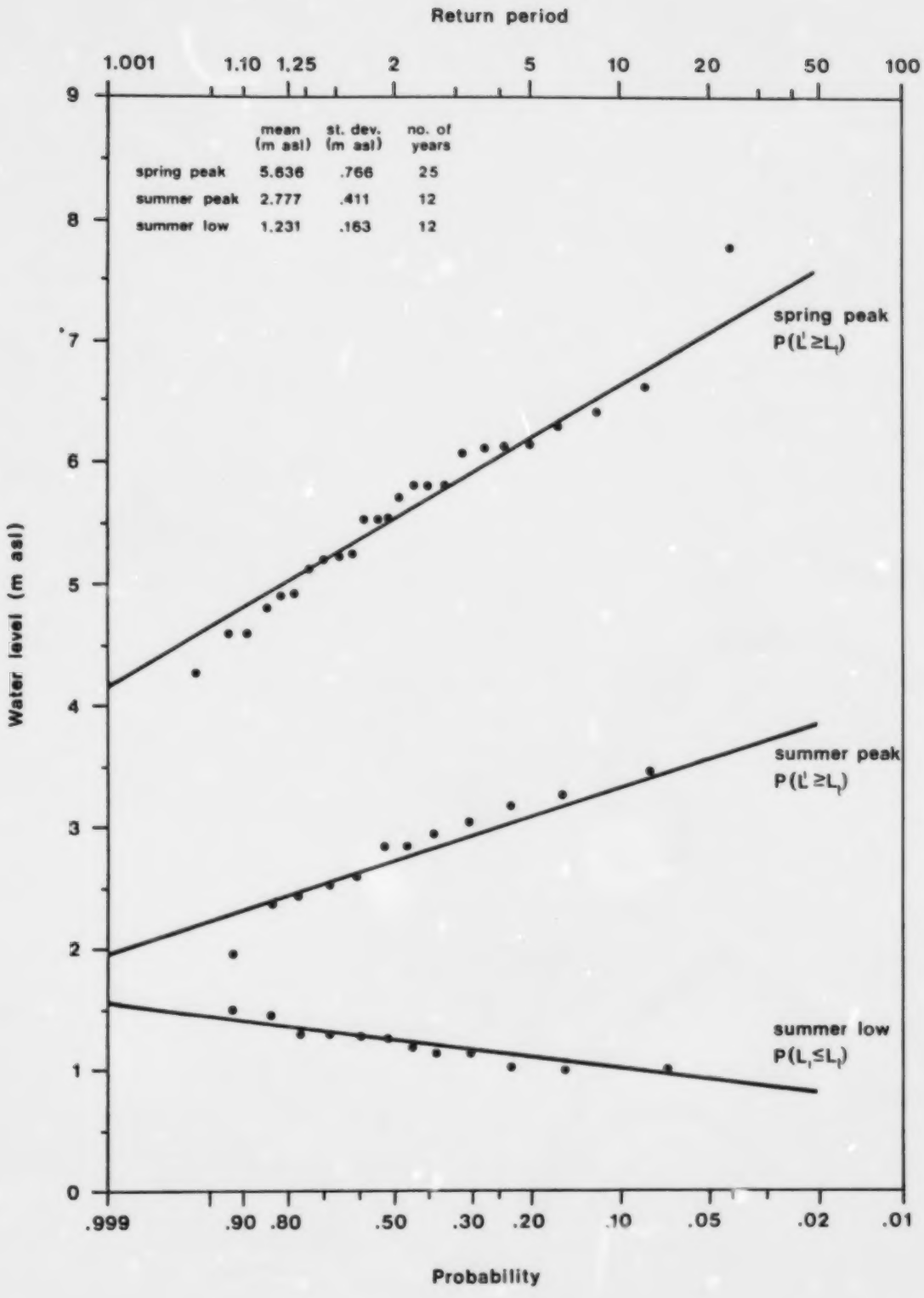


Fig. 14 Return periods of extreme spring and summer peaks, and summer low.

Summer peak water levels are considerably lower than the spring peaks, ranging from 3.430 to 1.929 m asl, with a mean of only 2.777 m asl. In fact, the spring peak is always greater than the summer peak, with the highest recorded summer peak being 0.87 m lower than the lowest recorded spring peak. In addition, the variation of the spring peaks is greater, with an observed standard deviation of .766 m, while the summer peaks have a standard deviation of .440 m. Lakes above about 3.3 m asl, or about 40% of all lakes, are flooded only every 5 years on average during the summer period, while lakes below about 2.0 m asl receive flood water every summer (Table 2). Lakes above 4 m asl have predicted summer flooding return periods in excess of 50 years.

Figure 14 also shows the probability distribution of the extreme low water levels recorded during the summer period. Since water levels can fall below 1 m asl, nearly all lakes in the study area can be cut off from the main Mackenzie River channels. Even with a return period of 2 years, the water level can drop to 1.25 m asl, cutting off approximately 90% of the lakes in the study area (Table 2). In effect, all these lakes have 'closure' using the definition given in the studies listed in Table 1, and very few lakes have 'no closure'.

Lake storage, in depth per unit lake area, varies greatly from lake to lake depending on the sill elevation. For example, the mean increase in storage during the spring period, for lakes with a sill of 1.0 m asl is 4.636 m of water, while for lakes with a sill of 5 m asl the mean value is only .636 m. The mean increase in storage for all lakes in the study area can be determined

by weighting the increase in storage, in .5 m asl elevation increments, by lake surface area. The result shows that the mean increase in lake storage is 3.914 m per unit lake area. This is probably an underestimate of the true lake storage, because it does not take into account the increase in lake area during the spring flood period. Assuming that this lake storage and the distribution of lake area versus elevation is representative of the entire delta, a total lake storage during the spring flood period for the Mackenzie Delta can be calculated from

$$L_S = \Delta S \quad A \quad P_A$$

where L_S is the total lake storage over the delta, ΔS is the mean change in lake storage in the study area, A is the delta area (12000 km^2), and P_A is the lake area as a percentage of total delta area (25%, Lewis, in prep.). The resultant mean lake storage is 1.17×10^{10} m^3. This represents over 7 days of discharge of the Mackenzie River above Arctic Red River, using the mean May-June discharge of 17,900 m^3/s. It must be realized that considerable error may be associated with this estimate, but it illustrates that lake storage is a significant hydrologic factor in the Mackenzie Delta. This lake storage has a major effect on the main channel water levels. Lake storage limits the increase in main channel levels during periods of rising stage, as water enters storage in the lakes, and slows the rate of decrease in channel levels during periods of falling stage, as the lake storage decreases.

6.3 Number and duration of events

The mean duration of the first event of the summer (Figure 15a, Table 2) varies from about 151 days for sill levels of only 1 m asl to only 3 days for the 5% of lakes with sill levels of 5.5 m asl. For the lowest elevation lakes, the duration is very consistent from year to year. In effect, water levels are above 1 m asl for the entire May 1 to September 30 study period. For higher levels, however, the variation from year to year increases rapidly. At 2 m asl for example, the mean duration is 75 days but the range is from 121 to only 26 days. This large range is due primarily to variations in the end of the spring high water period which may in some years extend well into the summer period. For increasing sill levels, the variation decreases since it is controlled exclusively by the spring event.

The first event of the study period occurs once per year for lakes with sill levels of 4 m asl and lower (Figure 16a), but for higher levels the mean number of events gradually decreases from 1 to .75 events per year at 5 m asl, to only .04 events per year at 7.5 m asl.

The events after the first event (i.e. those cases where the water level falls below a given level and then rises above it later in the year) are shown in Figure 15b. For the 1.0 m asl level there are few events per season (Figure 16b) and they are of short duration (Figure 15b), because the first event covers most of the summer period. For the 1.5 m asl level the number of subsequent events increases to a mean of 1.75 per year with a total duration

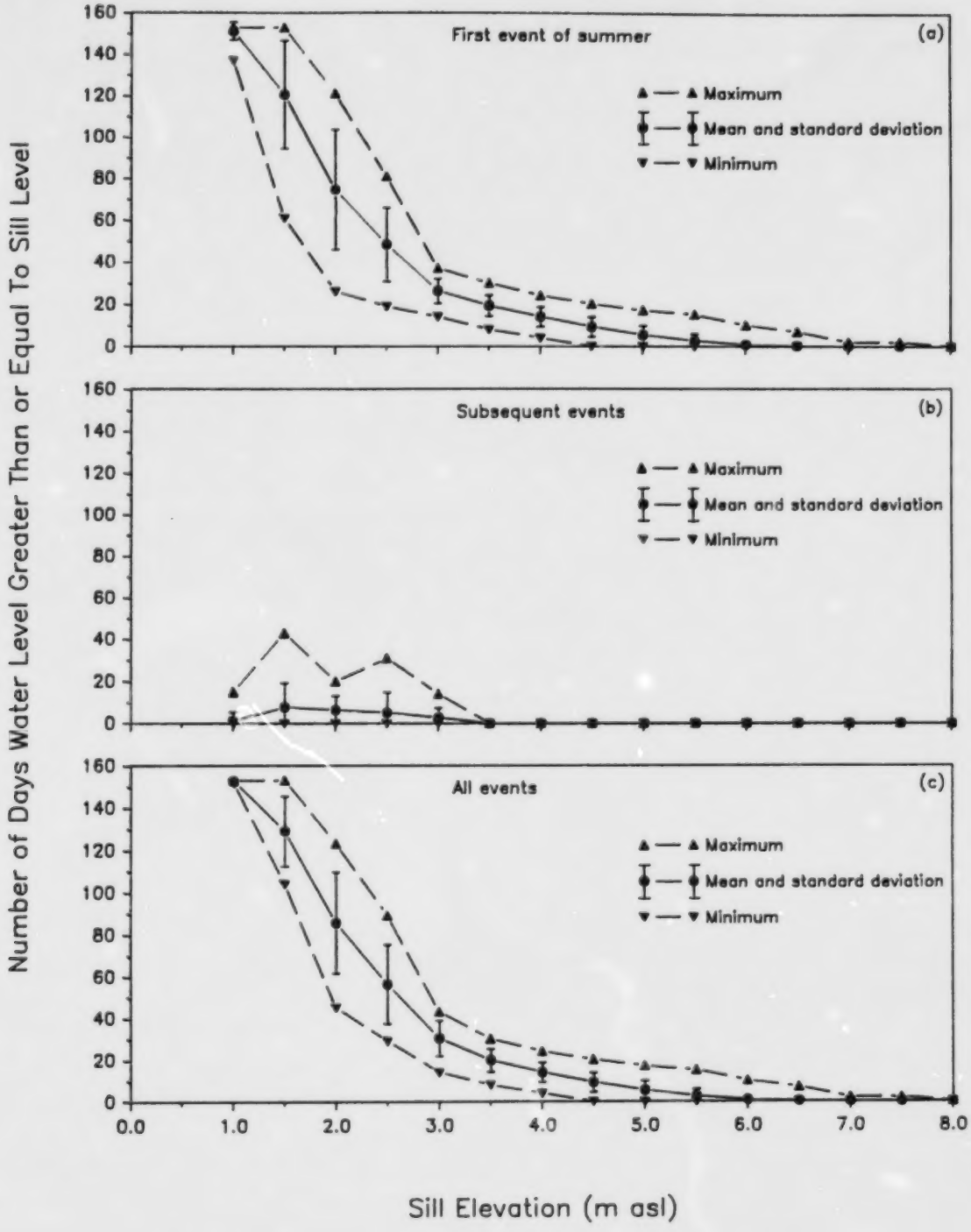


Fig. 15 Durations of first, subsequent, and combined events versus sill elevation.

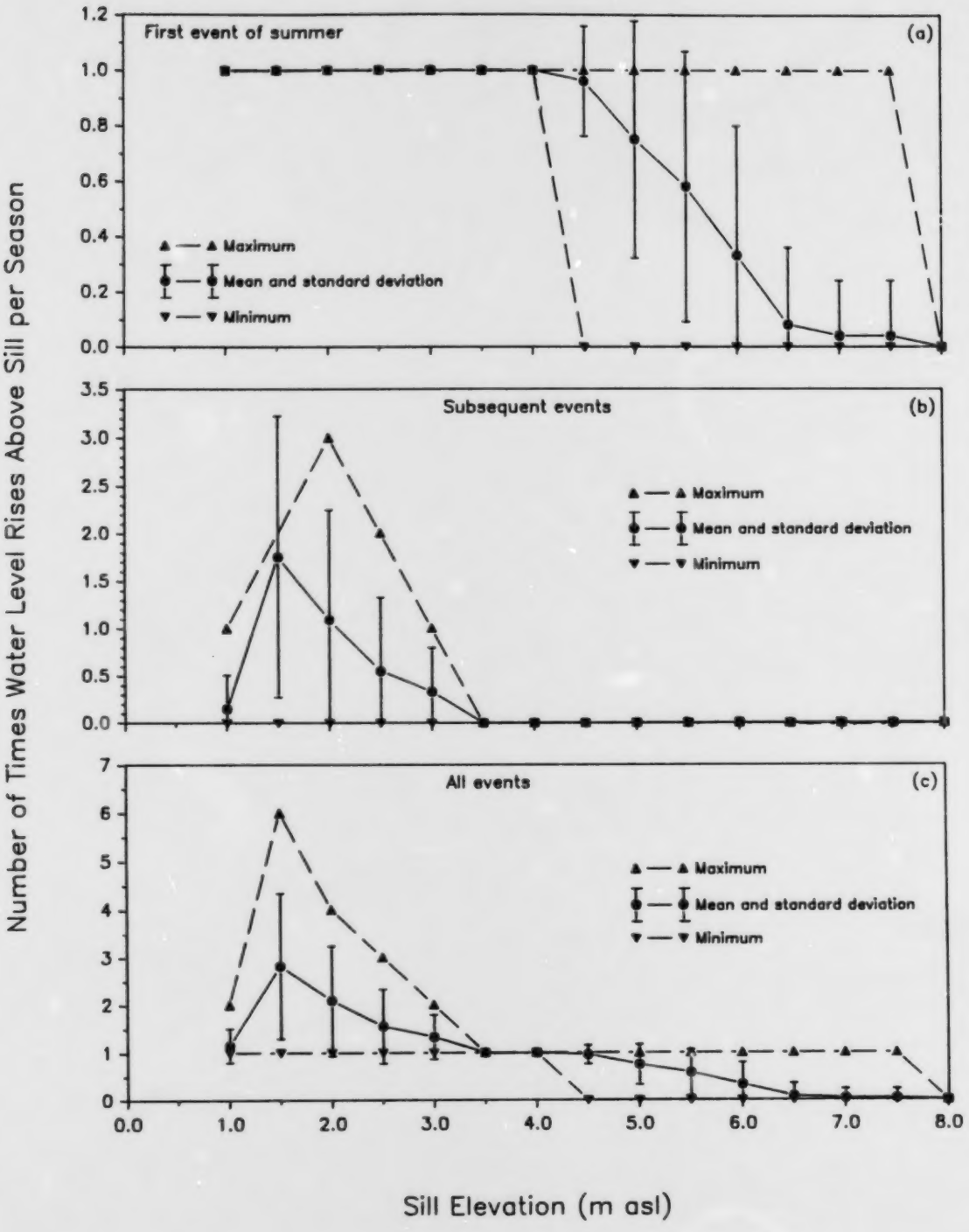


Fig. 16 Number of exceedances of sill elevation, for first, subsequent, and combined events.

of 7.8 days. Both the number of events and their combined durations decrease for higher levels, and for the 33% of lakes with sills greater than 3.5 m asl no subsequent events have been observed in 12 years of record. These lakes in effect receive no flood water after the spring break-up period. Since these subsequent events are very brief, the duration of all events combined, in days/season, is very similar to the duration of the first event alone. In fact, for levels above 3.5 m asl they are identical (i.e. the first event is the only event of the year).

6.4 Inflow events

During the time period when the main channel water level is above the lake sill elevation, small changes in channel level cause water to flow into or out of delta lakes. When the channel water level is above the lake sill, an increase in river level causes water to flow into the lake, while a decrease causes water to flow out of the lake (Figure 6). This is especially true for lakes with a single channel connecting them to the main channel, which were termed pulsating lakes by Marsh (1986b). The number of inflow events to these lakes can be estimated from the number of increases in Mackenzie River water level. Of the lakes studied in detail, South Lake and NRC Lake are of this type.

For lakes with a sill of 1 m asl, there are an average of 14 inflow events over the summer (Figure 17, Table 2). This number decreases rapidly until lakes at 3.5 m asl have only 1.5 inflow events per year, and those at higher

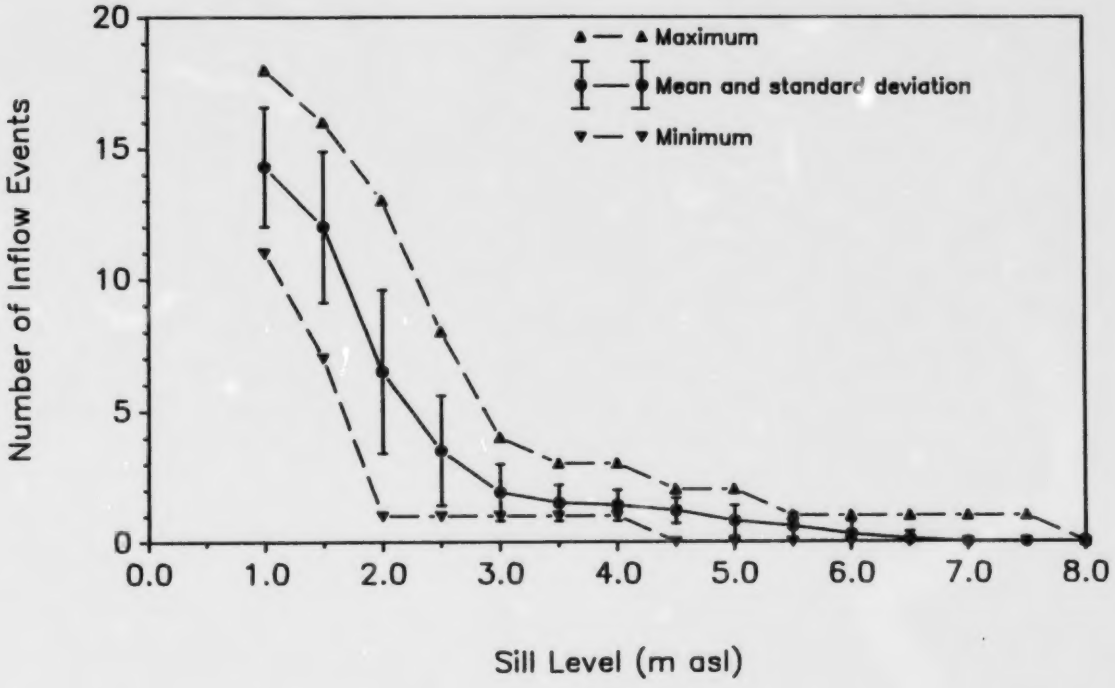


Fig. 17 Number of inflow events versus sill elevation.

levels (4.5 m and above) have less than 1 inflow per year on average. These inflow events are very important, controlling the input of sediment, chemicals, nutrients and energy to the lakes. Low lakes with as many as 14 inflow events over the summer would be expected to be very different from those higher lakes with only 1 inflow per year. At the lower sill levels the number of inflow events varies greatly from year to year. At 2 m asl for example, the mean is 6.5, with a range of from 1 to 13 events and a standard deviation of 3.1 events. With increasing level the variation decreases, so that at the higher levels the range is between 0 and 1 event per year.

6.5 Study lakes

Tables 3 and 4 summarize the flooding statistics for the three study lakes (Skidoo, South, and NRC) as determined from the above analysis of East Channel water levels.

South and Skidoo Lakes have similar sill elevations and therefore similar flooding statistics. Both lakes flood in mid May and remain flooded for much of the summer. Only during late summer are these lakes cut off from the Mackenzie River. The main difference between these two lakes is the number of inflow events. South Lake averages 13 per year, while Skidoo Lake would have fewer inflow events (although the exact number is difficult to determine) because it is connected to a large lake system.

Table 3: Lake Elevation and Return Period of Extreme Events

Lake	Sill elevation (m asl) Spring	Summer	Mean date of spring flooding	Return period of extreme events: spring flood	summer flood	summer cutoff
South	2.363	1.272	day 138	1.0	1.0	2.0
Skidoo	2.363	1.272	day 138	1.0	1.0	2.0
NRC	4.077	3.500	day 147	1.0	17.5	1.0

NOTE: 1. Spring sill level used to determine date of spring flood.

2. Summer sill level used to determine all other variables.

Table 4: Duration and Number of Events for the three Study Lakes

Lake	Mean duration above summer sill (days/season): first event	all events	Mean annual number of events	Mean annual number of inflow events
South	135	140	2	13.8
Skidoo	135	140	2	--
NRC	19	19	1	1.5

NOTE: Number of inflow events cannot be calculated for Skidoo Lake because it is part of a large lake system.

NRC Lake is higher than both South and Skidoo Lakes, and therefore has a very different flooding regime. It is flooded annually in the spring, but 9 days later on average than Skidoo or South Lakes. Once the spring flood has receded, NRC Lake usually is not flooded again that summer (Table 2). The duration of flooding is very short, averaging only 19 days.

Since the frequency and duration of flooding of NRC Lake are very different from either Skidoo or South Lake, the input of nutrients, chemicals, and sediment would be expected to be very different. Future work will be aimed at determining the implications of these variations in lake flooding.

7. PARTIAL DURATION SERIES ANALYSIS OF SPRING HIGH WATER LEVELS

In the following section the partial duration series will be used to analyse the spring high stage events in the study area. These extreme events are very important to the hydrology of the approximately 33% of lakes which are high-closure, and which are flooded potentially only during the brief spring flood period. Since these lakes are not viable without flooding (Marsh, 1986a,b), and they currently flood less than annually, they are very sensitive to small natural or anthropogenic changes in the flooding regime. The following analyses demonstrate the probabilities of the timing, magnitude, and duration of flooding for lakes with differing sill elevations.

7.1 Stationarity

Hirst et al. (1987) quote studies which suggest that an increase in peak flows occurred in certain basins in the Canadian west around 1950, and that a similar change may have occurred in the Mackenzie River basin around 1970. They indicate that peak spring discharge of the Mackenzie River at Norman Wells prior to 1971 was lower than normal, while since 1971/72 it has been 22% larger than the average for the period 1940 to 1985. In addition, the spring peak occurred earlier in the 1940 to 1971/72 period and later since that time.

The Norman Wells data must be interpreted cautiously, however, due to problems with determination of discharge during the spring ice break-up period. Direct measurement of peak discharge is impossible due to the high concentrations of moving ice and the occurrence of ice jams. As well, large errors are associated with estimates of peak discharge because the normal stage-discharge relationship is not applicable and adjustments for backwater are difficult to apply because of the variations in ice jamming from year to year. Since water level is easier to measure than discharge, it may be expected to provide a more consistent data base than discharge. However, it must be realized that water level is related to both discharge and ice jamming, and therefore to both local and basin-wide variables, making interpretation difficult.

The spring peak water level record for East Channel at Inuvik, when plotted as a percentage departure from the mean (Figure 18a), shows a pattern similar to that described by Hirst et al. (1987) for discharge at Norman Wells, but there

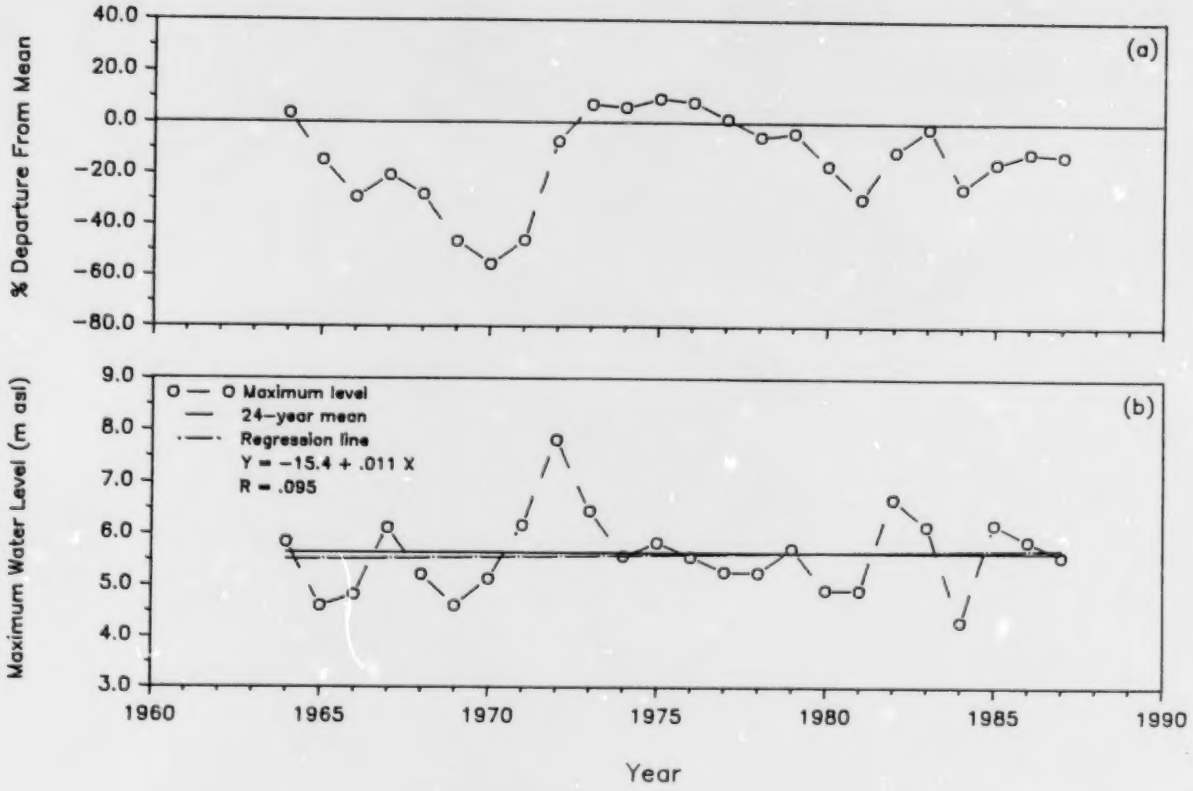


Fig. 18 Long-term trends in East Channel peak spring water levels:
(a) cumulative percentage of deviation from mean;
(b) regression through the annual series.

are significant differences. Figure 18a shows that peak water levels at East Channel were generally below normal prior to 1970, and above normal from 1971 to 1973. This is similar to the discharge pattern at Normal Wells. It is interesting to note that the highest water level recorded in 24 years at Inuvik (Figure 18b) occurred during this period, when Hirst et al. (1987) show that the regime switched from below to above normal at Norman Wells. Since 1974, however, peak water levels at Inuvik have been close to normal, while discharge at Normal Wells has continued to be above normal.

In general, the limited data for East Channel at Inuvik do not indicate a switch in regime in the early 1970's, nor does the time series indicate a long-term trend in the data. This is illustrated by the plot of annual peak levels versus time (Figure 18b), where the slope is not significantly different from zero at the .80 confidence limit. The data do show, however, that over the last 24 years, water levels at Inuvik have been characterized by short periods of alternately above or below normal water levels.

7.2 Timing

As discussed earlier, water levels exceed given truncations over a relatively short time span from the latter part of May to early June. This is illustrated in Figure 19 for the 4 m asl truncation. In this case the probability of the timing is normally distributed. The K-S test shows that the observed and predicted probability distributions for the 4 to 6 m asl

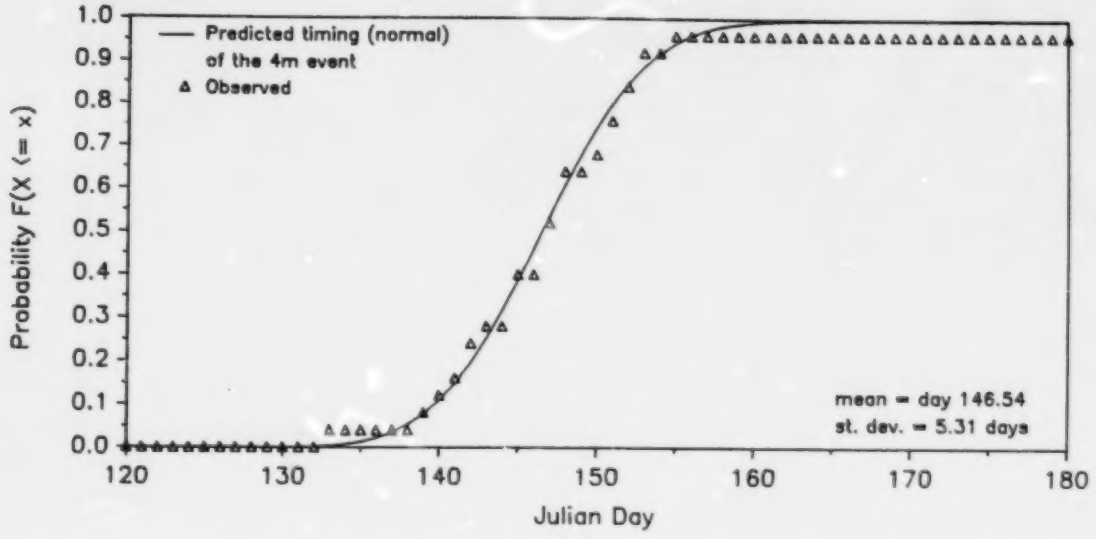


Fig. 19 Observed versus predicted (normal) timing of the 4m asl exceedance.

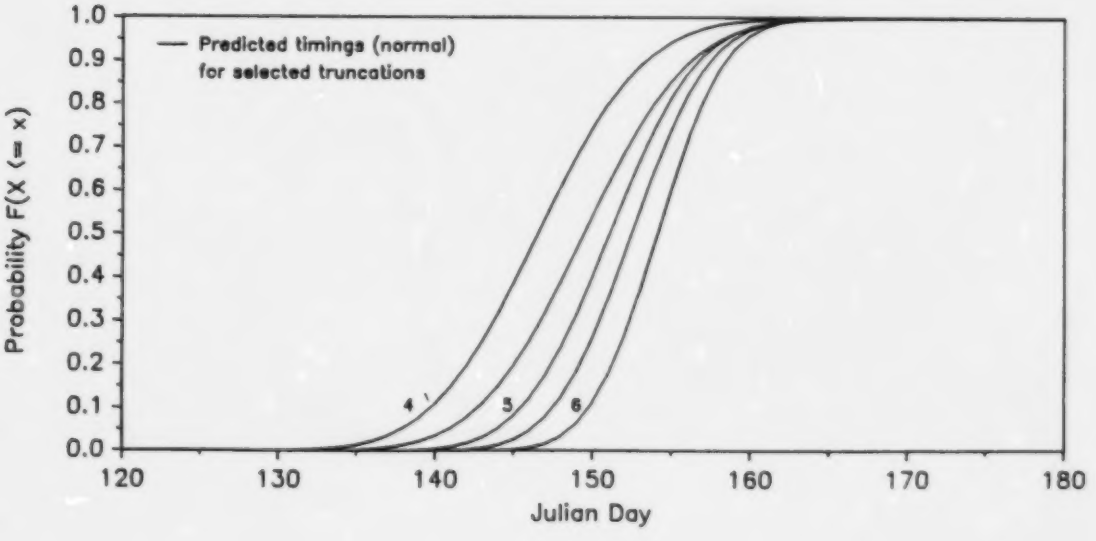


Fig. 20 Predicted (normal) timing of exceedance of the 4m to 6m asl truncations.

levels are not significantly different at the 0.8 level. Figure 20 illustrates the differences in timings for different truncations, with flooding occurring later with increasing elevation, and as indicated by the steepening curves, the variation decreases with increasing truncation level.

The curves shown in Figure 20 may be adjusted using equation 5, in order to predict the probability of an event occurring or not occurring by a given date. This procedure has the advantage of combining information on the probability of an extreme event, as in the annual series graph (Figure 14), and the timing of the event. For the 6 m asl level, for example, Figure 21 illustrates the observed versus predicted probability of 0 or 1 event occurring by given dates. The probability of having an event before day 148 is very low, but it increases slowly to about .33 by day 160 (Figure 21). If the 6 m exceedance has not occurred by day 160, it is very unlikely to happen at all. Figure 22 shows the predicted curves for all truncation levels. This illustrates that lakes at higher elevations begin to flood later and later in May or in early June, and that with higher elevation, the probability of flooding decreases.

7.3 Magnitude

If an event occurs, as predicted in the above section, the probability of the water level rising to a given height above the sill level is approximated by the exponential distribution (equation 7). Figure 23 shows a typical example for the 4.5 m asl truncation level. For this level and above, the observed

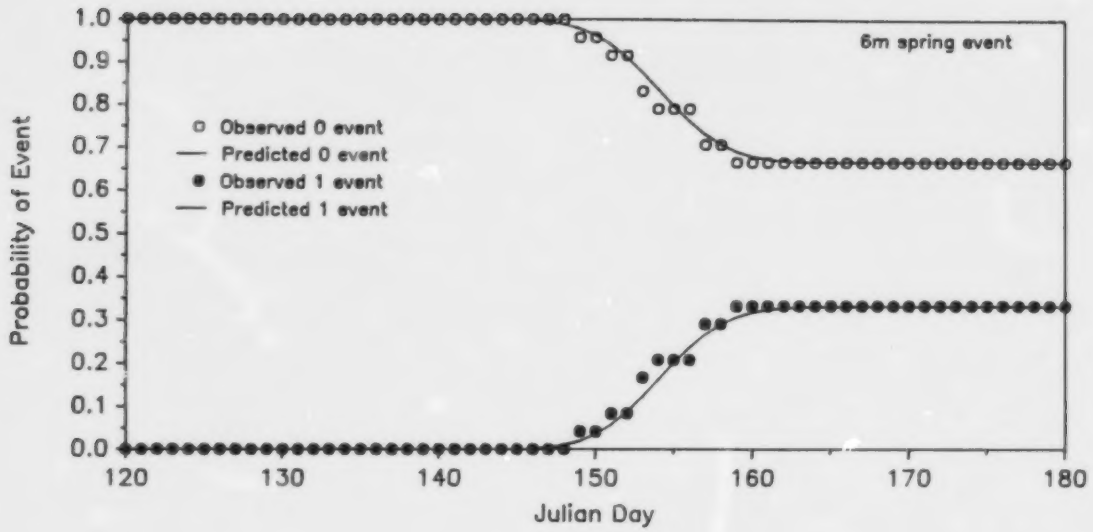


Fig. 21 Observed and predicted probabilities of 0 or 1 exceedance of the 6m asl truncation by a given day.

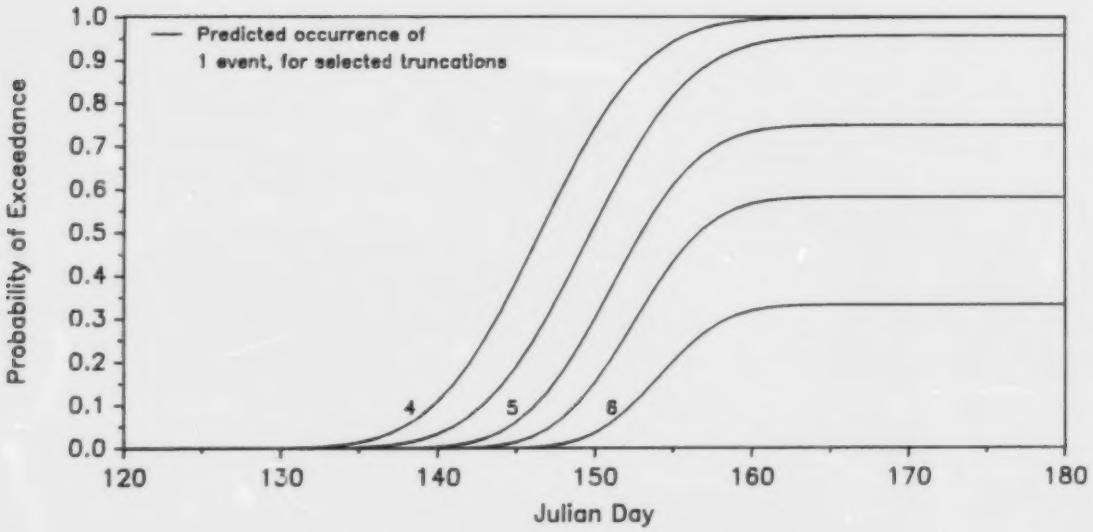


Fig. 22 Predicted probability of 1 exceedance by a given day, for the 4m to 6m asl truncations.

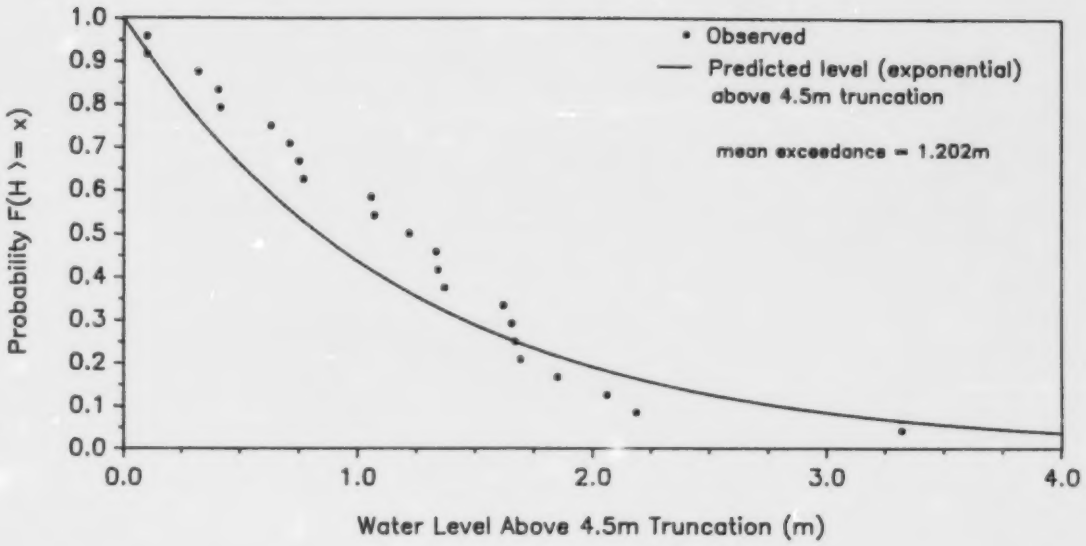


Fig. 23 Observed versus predicted (exponential) magnitude of water levels above the 4.5m asl truncation.

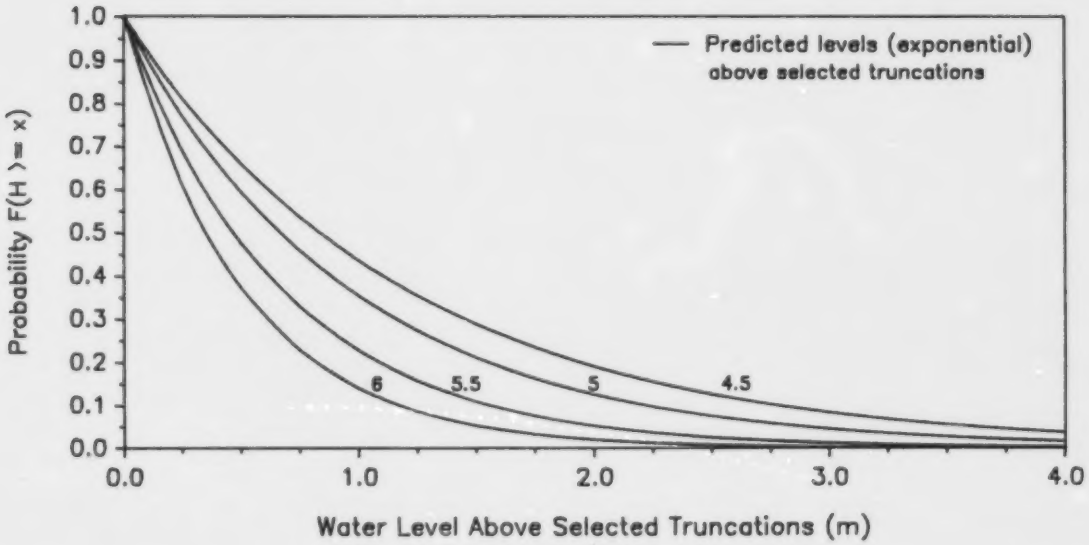


Fig. 24 Predicted (exponential) magnitude of water levels above the 4.5m to 6m asl truncations.

and predicted frequencies are not significantly different at the 0.80 level. However, for the 4 m level, the predicted values do not fit the observed. The poor fit probably occurs because the 4 m high water level does not meet the criterion of being 'large enough'. For increasing truncation levels the mean exceedance level decreases from 1.64 m at 4 m asl to only .51 m at 6 m, and the probability of the sill being exceeded by a given amount also decreases (Figure 24).

The implication to lake hydrology is that lakes with higher sill elevations are flooded less frequently, and when they are flooded the depth of flooding is less. Since depth of flooding can be taken as an approximation of the inflow volume to the lake, this implies that the sediment and nutrient input to these lakes decreases with increasing level.

7.4 Duration

As indicated previously, studies have shown that the exponential distribution is a good fit for the duration of events above given truncations. However, for East Channel, the predicted exponential is significantly different from the observed at the 0.80 level for truncations of 4, 4.5, and 5 m asl. Only for the 5.5 m (Figure 25b) and 6 m asl levels is the observed not significantly different. This may be due to a number of factors. First, as Waylen and Woo (1983) emphasize, the events must be sufficiently large. They analyse events having return periods of 1.4 years or greater. For East Channel, the 1.4-year flood corresponds to a peak level of 5.15 m asl, and

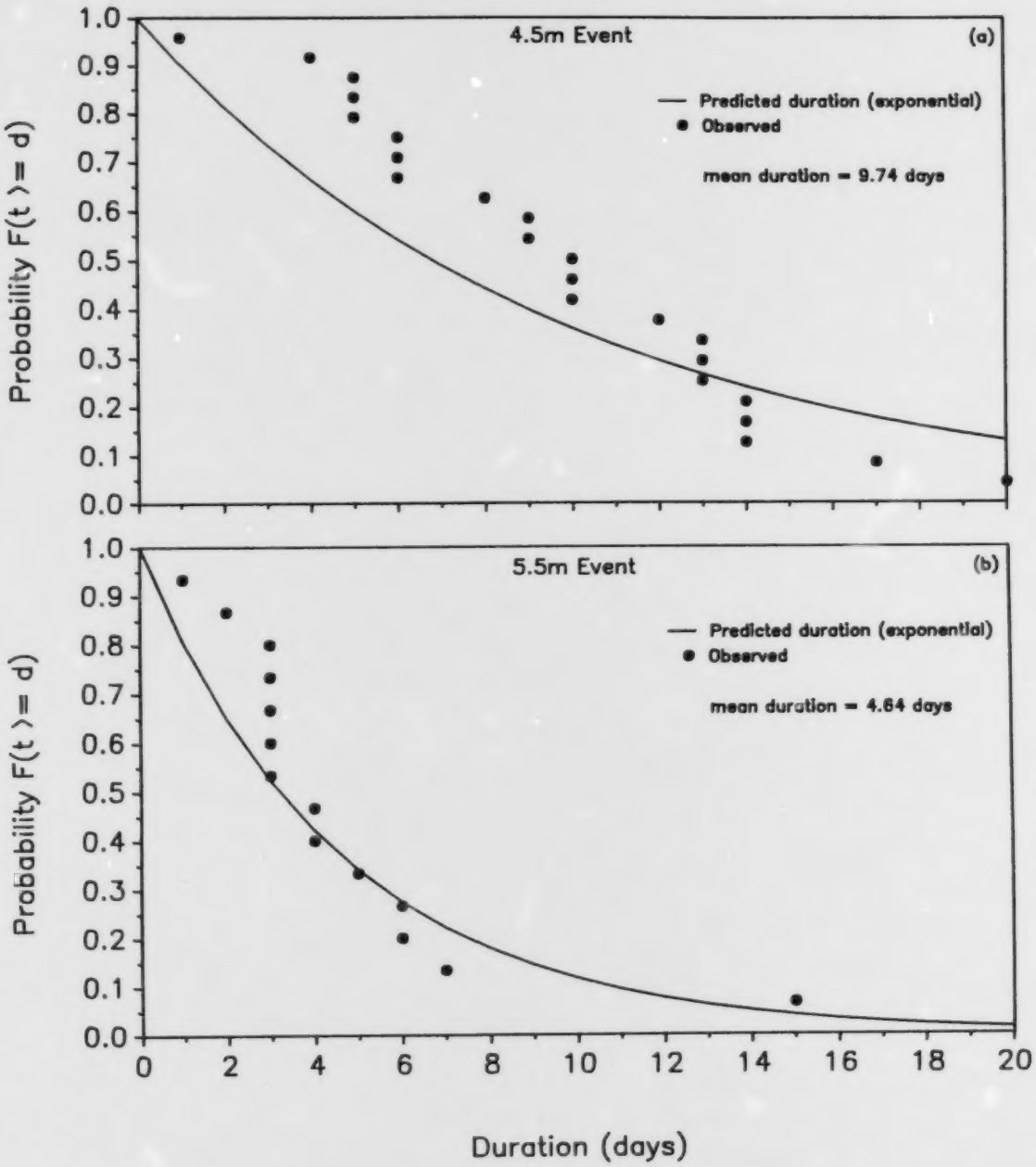


Fig. 25 Observed versus predicted (exponential) duration of exceedance of the 4.5m and 5.5m asl truncations.

therefore only the 5.5 m asl and 6 m asl truncations are high enough to fit the criteria used by Waylen and Woo. However, it is interesting to note that the observed timing and magnitude were in agreement with the predicted for the 4.5 m asl level and above. This corresponds to a return period of only 1.026 years.

The poor fit between observed and predicted durations at lower elevations (Figure 25a) is due to the small proportion of events having very short duration. In fact, even though the exponential distribution predicts that approximately 34% of all events at the 4.5 m truncation have durations of less than 4 days, there was only 1 such event in 24 years of record. Figure 25a shows that at the 4.5 m asl level there is a sufficiently small number of low magnitude events, but these are of longer duration than predicted by the exponential. This is probably related to ice jamming and backwater processes that control the duration of these events, and which cannot be assimilated by the model.

8. CONCLUSIONS

1. Lake sill elevation was determined for 132 lakes in the Inuvik area. These data show that the lakes cover a continuum of sill elevations from about 1.0 to 6.0 m asl. These differences in elevation control variations in the lake hydrologic regime.

2. Depending on the variable of interest, from eleven to twenty-four years of Mackenzie River East Channel water levels were analysed in conjunction

with the data on lake sill elevations. This allowed a determination of the timing, frequency, number, and duration of flooding events, and the number of inflow events for lakes with different sill elevations.

3. These data show that lakes below approximately 4 m asl (about 67% of all lakes) flood annually in the spring, while those above 4 m asl do not flood annually. The highest elevation lakes have a flood frequency of about 3 years. During the summer period lakes above about 3.5 m asl do not receive water from the Mackenzie River. Lakes below this elevation receive Mackenzie River water for varying periods of time each summer.

4. During the summer, water levels drop to about 1.25 m asl every two years on average. This implies that between 90 and 95% of all lakes are cut off from the main channel at fairly frequent intervals.

5. The partial duration series analysis was successfully applied to the timing, magnitude, and duration of spring flood events for lakes of different sill levels. This analysis allows the probability of spring flooding to be modelled for any lake in the study area.

6. It is believed that the differences in the hydrologic flooding regime described in this study play a major role in controlling the physical and biological conditions of delta lakes. However, further work is required to determine the effects of different flooding regimes on the chemical, nutrient, and sediment balance, and biological productivity of lakes with different sill elevations.

REFERENCES

Bigras, S. C., 1987. Lake Regimes, Mackenzie Delta, N.W.T., 1984. Northern Hydrology Section, Surface Water Division, National Hydrology Research Institute, Environment Canada, Saskatoon, Sask., NHRI Contribution No. 87005, 52 pp.

British Columbia Hydro, 1985. Liard Hydroelectric Development, Mackenzie Delta Environmental Hydrology, Report # ESS-92.

Brown, R. J. E., 1957. Observations on break-up in the Mackenzie River and its delta in 1954. Journal of Glaciology, 3(22), 133-142.

Coleman, J. M., 1976. Deltas: Processes of Deposition and Models for Exploration. Continuing Education Publication Company, Inc., Champaign, Ill., 102 pp.

Coleman, J. M., H. H. Roberts, and O. K. Huh, 1986. Deltaic landforms. In: Geomorphology From Space, A Global Overview of Regional Landforms. N. M. Short and R. W. Blair Jr. (eds.), National Aeronautics and Space Administration, Washington, D. C., pp. 317-352.

Cordes, L.D. and D.S. McLennan, 1984. The Estimation of Sedimentation Rates Using ^{137}Cs in Lakes of the Mackenzie Delta. L. Cordes and Associates, Calgary, Alta., for the British Columbia Power and Hydro Authority, Vancouver, B.C. 55 pp.

Cramer, H. and M. R. Leadbetter, 1967. Stationary and Related Stochastic Processes. Wiley, New York, 348 pp.

Crutcher, H. L., 1975. A note on the possible misuse of the Kolmogorov-Smirnov test. Journal of Applied Meteorology, 14, 1600-1603.

Environment Canada, 1987. Surface Water Data Reference Index, Canada, 1986. Inland Waters Directorate, Water Resources Branch, Ottawa, Ont., 401 pp.

Gill, D., 1971. Vegetation and Environment in the Mackenzie River Delta, N. W. T.: A Study in Sub-Arctic Ecology. Unpublished Ph.D. thesis, Department of Geography, University of British Columbia, Vancouver, B. C., 694 pp.

Haan, C. T., 1977. Statistical Methods in Hydrology. Iowa State University Press, Ames, 378 pp.

Hirst, S. M., M. Miles, S. P. Blachut, L. A. Goulet, and R. E. Taylor, 1987. Quantitative Synthesis of the Mackenzie Delta Ecosystems (Main Volume). Prepared for Inland Waters Directorate, Environment Canada, by Applied Ecology Consultants, North Vancouver, B. C.

Lewis, C. P., in preparation. Mackenzie Delta Sedimentary Environments and Processes. Report to Inland Waters Directorate, Environment Canada, Ottawa.

Lilliefors, H. W., 1967. On the Kolmogorov-Smirnov test for normality with mean and variance unknown. Journal of the American Statistical Association, 62, 399-402.

---------- 1969. On the Kolmogorov-Smirnov test for the exponential distribution with mean unknown. Journal of the American Statistical Association, 64, 387-389.

MacKay, J. R., 1963. The Mackenzie Delta Area, N. W. T. Geological Survey of Canada Misc. Report 23, 202 pp.

Marsh, P., 1986a. Modelling water levels for a lake in the Mackenzie Delta. Proceedings of the Symposium: Cold Regions Hydrology, University of Alaska, Fairbanks; July. American Water Resources Association, D. L. Kane (ed.), 23-29.

--------- 1986b. Hydrology of Mackenzie Delta Lakes. Paper submitted to Northern Rivers and Lakes Workshop; Knowing the North: Integrating Tradition, Technology and Science. Boreal Institute for Northern Studies, University of Alberta, Edmonton, Alta., November; (in press).

--------- 1987. Factors limiting snow-melt run-off in a permafrost environment. Proceedings of the Fifty-fifth Annual Meeting, Western Snow Conference, Vancouver, B. C., April 14-16, 61-68.

Marsh, P. and Hey, M. 1988. The flooding hydrology of Mackenzie Delta Lakes. National Hydrology Research Institute Contribution No. 88008, Saskatoon, Sask.

McElhanney Surveying and Engineering Ltd., 1983. Mackenzie Delta Inertial Survey. Prepared for Inland Waters Directorate, Western and Northern Region, Environment Canada, Regina, Sask.

Ostrick, J., 1987. Personal communication. (Laboratory Manager, Inuvik Scientific Resource Centre, Inuvik, N.W.T.).

Pearce, C. M., 1986. The Distribution and Ecology of the Shoreline Vegetation in the Mackenzie Delta, N. W. T. Unpublished Ph.D. thesis, Department of Geography, University of Calgary, Calgary, Alta., 400 pp.

Peterson, E. B., L. M. Allison, and R. D. Kabzems, 1981. Alluvial Ecosystems. Mackenzie River Basin Committee, Mackenzie River Basin Study Report Supplement 2, 129 pp.

Prowse, T. D. and P. Marsh, 1987. Atmospheric and hydrothermal heat flows to intact and fragmented ice covers. Paper to the International Association for the Hydrological Sciences Workshop on River Ice, University of British Columbia, Vancouver, B. C., August 12, 21 pp. (in press).

Sherstone, D. A., T. D. Prowse, and H. Gross, 1986. The development and use of "hot-wire" and conductivity-type ice measurement gauges for determination of ice thickness in Arctic rivers. Proceedings of the Symposium: Cold Regions Hydrology, University of Alaska, Fairbanks; July. American Water Resources Association, D. L. Kane (ed.), 121-129.

Taesombut, V. and V. Yevjevich, 1978. Use of Partial Flood Series for Estimating Distribution of Maximum Annual Flood Peak. Colorado State University, Hydrology Paper No. 97, 71 pp.

Todorovic, P., 1978. Stochastic models of floods. Water Resources Research, 14(2), 345-356.

Waylen, P. R. and M. K. Woo, 1983. Stochastic analysis of high flows in some central British Columbia rivers. Canadian Journal of Civil Engineering, 10(2), 205-213.

Woo, M. K. and P. R. Waylen, 1984. Areal prediction of annual floods generated by two distinct processes. Journal of Hydrological Sciences, 29(1,3), 75-88.

Yevjevich, V., 1972. Probability and Statistics in Hydrology. Water Resources Publications, Fort Collins, Colo., 294 pp.

APPENDICES

A. Mackenzie River East Channel - Daily Water Levels

A1. Instantaneous water levels - Brown (1957) and Inuvik Scientific Resource Centre.
A2. Mean daily water levels - Water Survey of Canada.
A3. Annual hydrographs.

B. Summary Tables

B1. Julian dates of exceedance of given truncations for event 1.
B2. Duration of water levels greater than or equal to a given truncation level for event 1, subsequent events, and all events.
B3. Extreme high and low events.
B4. Number of occurrences of event 1, subsequent events, and all events.
B5. Number of inflow events above given sill levels.

C. Partial Duration Series

C1. Summary table.
C2. Julian dates of exceedance of given truncations - normal distribution.
C3. Probability of having zero or one event by a given date.
C4. Magnitude of peak levels above given truncations.
C5. Duration of spring event above given truncation levels.

D. Lake Flooding

D1. Map of study lakes.
D2. Lakes sorted by date of flooding (sill elevations).
D3. Lakes sorted by lake number.
D4. Lakes sorted by lake area.
D5. Summary of spring and summer lake sill elevations.

APPENDIX A: Mackenzie River East Channel - Daily Water Levels

A1. Instantaneous water levels - Brown (1957).
- Inuvik Scientific Resource Centre.

Water levels, East Channel Mackenzie River at Inuvik (m asl)

Julian day	1954	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
120											
121											
122											
123											
124											
125											
126											
127											
128										1.675	1.929
129										2.133	1.929
130					1.675		1.929			2.107	2.056
131			1.269		1.752		2.082			2.107	2.158
132			1.371	1.116	1.853		2.259	1.371		2.107	2.310
133			1.523	1.243	1.980		2.412	1.421		2.133	2.488
134			1.675	1.371	2.133		2.564	1.421		2.209	2.691
135			1.802	1.624	2.259	1.371	2.716	1.497		2.234	2.869
136			1.878	1.802	2.386	1.497	2.869	1.497		2.234	3.072
137			1.980	2.082	2.488	1.573	3.021	1.624	3.148	2.259	3.428
138			2.031	2.310	2.640	1.726	3.148	1.752	3.301	2.335	3.758
139			2.031	2.615	2.793	1.878	3.301	1.878	3.504	2.437	4.114
140			2.056	2.869	2.996	2.031	3.478	2.005	3.682	2.514	4.393
141			2.082	3.097	3.148	2.209	3.606	2.133	4.114	2.666	4.444
142			2.158	3.276	3.301	2.335	3.783	2.234	4.215	2.869	4.444
143			2.310	3.402	3.453	2.488	3.859	2.386	4.520	3.072	4.520
144		1.269	2.488	3.529	3.580	2.666	3.936	2.488	4.749	3.352	4.926
145		1.421	2.716	3.606	3.682	2.793	4.291	2.640	5.002	3.555	5.155
146		1.650	2.996	3.809	3.859	2.920	4.393	2.945	5.282	3.809	5.333
147		1.802	3.225	3.936	3.936	3.021	4.419	3.402	5.409	4.012	5.587
148		2.005	3.428	4.038	4.139	3.148	4.444	3.707	5.485	4.266	5.764
149		2.209	3.580	4.419	4.342	3.250	4.393	3.783	5.587	4.723	6.069
150	3.61	2.437	3.809	4.190	4.419	3.428	4.393	3.859	5.739	5.231	6.450
151	4.16	2.640	3.987	4.190	4.571	3.631	4.520	4.190	6.171	5.587	6.044
152	4.43	3.021	4.190	4.240	4.444	3.910	4.571	4.545	5.841	5.790	5.663
153	4.82	4.088	4.368	4.291	4.850	4.571	4.596	4.800	5.383	5.993	5.282
154	5.14	4.495	4.419	4.317	5.206	4.621	4.596	5.130	4.926	6.145	5.002
155	5.38	5.028	4.419	4.444	5.307	4.672	4.520	5.002	4.749	6.324	4.749
156	5.59	5.130	4.393	4.825	5.663	4.825	4.444	4.774	4.342	6.526	4.419
157	5.63	5.587	4.342	4.647	6.044	5.028	4.012	4.520	3.987	6.781	4.190
158	5.86	5.688	4.368	4.698	5.815	5.206	3.783	4.317	3.733	6.907	4.088
159	6.32	5.841	4.444	4.596	5.409	4.977	3.453	3.885	3.453	7.822	4.038
160	5.82	5.536	4.596	4.291	5.130	4.647	3.377	3.707	3.225	7.593	3.987
161	5.21	5.282	4.266	3.987	5.028	4.469	3.352	3.504	3.097	6.984	3.809
162	4.53	4.977	3.961	3.733	4.240	4.063	3.174	3.377	2.971	6.577	3.631
163	4.11	4.800	3.707	3.453	4.114	3.987	2.996	3.225	2.869	6.247	3.555
164		4.419	3.478	3.276	4.012	3.834	2.844	3.123	2.742	5.917	3.453
165		4.139	3.225	2.971	3.936	3.682	2.767	2.996	2.666	5.587	3.326
166		3.936	3.097	2.818	3.859	3.402	2.691	2.996	2.615	5.181	3.225
167		3.783	2.945	2.716	3.606	3.199	2.640	2.971	2.564	4.850	3.148
168			2.869	2.666	3.428	3.148	2.564	2.945	2.539	4.672	3.097
169			2.818	2.590	3.301	3.123	2.488	2.844	2.514	4.495	3.021
170			2.716		3.199	2.971	2.412	2.793	2.514	4.342	2.971
171			2.590		3.047	2.818	2.361	2.793	2.488	4.190	2.920
172						2.844				4.012	
173											
174											
175											
176											
177											
178											
179											
180											
181											

· 1954 data from Brown, R. J. E.; 1964-1973 data from Inuvik Research Lab.

A2. Mean daily water levels - Water Survey of Canada.

Water levels, East Channel Mackenzie River at Inuvik (m asl)

Julian day	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1		1.153	1.068		0.79	0.955			0.753	0.916				1.166
2		1.193	1.068		0.8	0.965			0.753	0.913				1.173
3		1.208	1.065		0.818	0.955			0.772	0.913				1.179
4		1.208	1.056		0.836	0.934			0.802	0.912			1.314	1.182
5		1.202	1.056		0.848	0.931			0.823	0.921			1.309	1.185
6		1.285	1.053		0.862	0.946	1.046		0.834	0.925			1.315	1.196
7		1.385	1.062		0.875	0.934	1.05		0.839	0.927			1.315	1.202
8		1.33	1.077		0.892	0.937	1.05		0.832	0.924			1.326	1.204
9		1.288	1.089		0.901	0.968	1.05		0.83	0.922			1.338	1.215
10		1.26	1.105		0.915	0.98			0.843	0.923			1.351	1.223
11		1.251	1.111		0.923	0.971			0.861	0.924			1.361	1.225
12		1.245	1.129		0.934	0.961			0.877	0.936		0.629	1.375	1.228
13		1.236	1.135		0.953	0.971			0.877	0.949		0.64	1.391	1.23
14		1.224	1.147		0.957	0.968			0.869	0.962		0.676	1.407	1.238
15		1.233	1.16		0.966	0.968			0.868	0.957		0.678	1.417	1.238
16		1.239	1.169	1.266	0.98	0.968			0.888	0.965		0.673	1.416	1.239
17		1.239	1.187	1.266	0.988	0.958			0.904	0.972		0.67	1.421	1.231
18		1.236	1.202	1.265	0.997	0.965			0.896	0.97		0.673	1.436	1.225
19		1.233	1.217	1.266	1.007	0.989			0.911	0.97		0.721	1.445	1.225
20		1.23	1.236	1.269	1.014	0.998			0.946	0.975		0.752	1.459	1.222
21		1.224	1.251	1.277	1.023	1.001			0.955	0.971		0.781	1.472	1.22
22		1.217	1.26	1.285	1.034	0.998			0.947	0.967		0.813	1.482	1.219
23		1.221	1.266	1.286	1.038	0.992			0.953	0.968		0.836	1.485	1.227
24		1.221	1.275	1.281	1.045	0.983			0.951	0.98		0.824	1.498	1.224
25		1.221	1.291	1.278	1.048	0.98	1.09		0.947	0.988		0.805	1.503	1.223
26		1.224	1.3	1.281	1.057	0.992	1.09		0.943	0.999		0.799	1.5	1.229
27		1.227	1.318	1.283	1.06	0.998	1.089		0.944	1.001		0.818	1.505	1.233
28		1.233	1.327	1.283	1.061	0.998	1.089		0.96	1.002		0.821	1.514	1.233
29		1.248	1.33	1.285	1.06	0.998	1.089		0.955	1.002		0.817	1.514	1.235
30	1.272	1.254	1.333	1.287	1.058	1.001	1.09		0.949	1.013		0.826	1.499	1.243
31		1.26	1.333	1.291	1.057	1.004	1.091		0.936	1.017		0.833	1.489	1.249
32		1.269	1.33	1.293	1.059	1.01	1.092		0.94	1.018		0.836	1.494	1.249
33		1.275	1.327	1.293	1.065	1.013	1.095		0.937	1.012		0.838	1.503	1.254
34		1.278	1.324	1.293	1.062	1.013	1.098		0.947	1.011		0.836	1.511	1.258
35		1.278	1.33	1.293	1.056	1.025	1.098		0.958	1.02		0.836	1.519	1.259
36		1.278	1.336	1.296	1.059	1.047	1.102		0.965	1.034		0.849	1.527	1.259
37		1.278	1.339	1.299	1.066	1.062	1.111		0.96	1.042		0.86	1.526	1.26
38		1.275	1.342	1.301	1.069	1.077	1.116		0.956	1.04		0.876	1.521	1.264
39		1.278	1.352	1.301	1.072	1.089	1.115		0.955	1.043		0.888	1.516	1.276
40		1.282	1.364	1.299	1.08	1.083	1.12		0.954	1.059		0.883	1.508	1.281
41		1.282	1.379	1.296	1.086	1.074	1.126		0.965	1.076		0.892	1.511	1.288
42		1.282	1.379	1.295	1.094	1.068	1.141		0.967	1.07		0.907	1.509	1.29
43		1.285	1.376	1.298	1.101	1.068	1.141		0.963	1.058		0.921	1.502	1.293
44		1.288	1.376	1.3	1.103	1.071	1.142		0.959	1.069		0.936	1.506	1.295
45		1.297	1.376	1.301	1.108	1.077	1.145		0.968	1.079		0.949	1.505	1.293
46		1.3	1.376	1.302	1.115	1.089	1.151		0.972	1.09		0.964	1.51	1.288
47		1.3	1.376	1.303	1.113	1.093	1.157		0.992	1.098		0.975	1.509	1.287
48		1.303	1.379	1.303	1.118	1.099	1.165		0.991	1.082		0.984	1.508	1.289
49		1.306	1.388	1.304	1.12	1.108	1.174		0.994	1.076		1	1.508	1.29
50		1.312	1.391	1.306	1.12	1.117	1.184		0.997	1.085		1.007	1.512	1.291
51		1.315	1.397	1.305	1.12	1.129	1.195		0.996	1.084		1.016	1.518	1.295
52		1.312	1.397	1.304	1.127	1.138	1.199		1.009	1.08		1.016	1.518	1.296
53		1.309	1.403	1.305	1.136	1.144	1.197		1.016	1.076		1.012	1.524	1.295
54		1.306	1.4	1.305	1.157	1.147	1.202		1.015	1.073		1.014	1.53	1.298
55		1.318	1.4	1.306	1.156	1.15	1.207		1.016	1.072		1.016	1.527	1.3
56		1.33	1.397	1.304	1.155	1.153	1.21		1.022	1.073		1.013	1.53	1.3
57		1.333	1.397	1.301	1.154	1.16	1.212		1.029	1.08		1.004	1.538	1.312
58		1.336	1.4	1.297	1.162	1.169	1.212		1.031	1.092		1.01	1.541	1.319
59		1.339	1.397	1.307	1.166	1.175	1.217		1.029	1.094		1.023	1.54	1.328
60		1.342	1.394	1.305	1.164	1.166	1.222		1.034	1.095		1.03	1.538	1.327

61		1.342	1.385	1.3	1.166	1.163	1.224		1.047	1.105	1.037	1.536	1.327
62		1.349	1.382	1.297	1.172	1.175	1.224		1.062	1.114	1.046	1.533	1.327
63		1.349	1.385	1.298	1.176	1.181	1.225		1.063	1.126	1.051	1.532	1.332
64		1.349	1.388	1.299	1.176	1.199	1.232		1.058	1.137	1.052	1.533	1.335
65		1.352	1.382	1.3	1.181	1.208	1.232		1.061	1.141	1.062	1.536	1.336
66		1.349	1.379	1.303	1.188	1.214	1.234		1.06	1.143	1.061	1.537	1.343
67		1.352	1.376	1.304	1.196	1.221	1.242		1.059	1.151	1.068	1.539	1.348
68			1.376	1.307	1.198	1.227	1.251		1.057	1.155	1.076	1.541	1.351
69			1.382	1.31	1.198	1.23	1.256		1.066	1.168	1.091	1.542	1.353
70			1.382	1.311	1.206	1.23	1.255		1.067	1.168	1.083	1.546	1.358
71		1.349	1.385	1.311	1.204	1.23	1.256		1.068	1.168	1.081	1.547	1.362
72		1.355	1.391	1.312	1.199	1.233	1.263		1.078	1.17	1.086	1.538	1.363
73		1.367	1.4	1.313	1.202	1.233	1.275		1.081	1.176	1.091	1.541	1.368
74		1.373	1.403	1.313	1.206	1.242			1.091	1.174	1.089	1.541	1.371
75		1.379	1.4	1.311	1.211	1.254	1.278		1.105	1.174	1.102	1.543	1.375
76		1.385	1.394	1.311	1.225	1.257	1.281		1.108	1.176	1.11	1.545	1.381
77		1.388	1.394	1.312	1.229	1.257	1.284		1.102	1.191	1.107	1.543	1.384
78	1.4	1.397	1.391	1.313	1.229	1.257	1.299		1.089	1.203	1.122	1.545	1.384
79		1.403	1.394	1.312	1.23	1.26	1.304		1.088	1.215	1.126	1.547	1.385
80		1.41	1.394	1.312	1.232	1.266	1.309		1.1	1.211	1.127	1.554	1.391
81		1.413	1.397	1.313	1.231	1.266	1.311		1.112	1.228	1.129	1.56	1.391
82		1.428	1.403	1.314	1.234	1.266	1.321		1.114	1.233	1.136	1.557	1.389
83		1.434	1.406	1.314	1.237	1.272	1.32		1.111	1.242	1.144	1.557	1.394
84		1.434	1.403	1.313	1.245	1.275	1.328		1.116	1.255	1.147	1.559	1.402
85		1.434	1.403	1.313	1.25	1.278	1.332		1.118	1.255	1.156	1.564	1.405
86		1.449	1.403	1.313	1.253	1.285	1.351		1.128	1.253	1.162	1.558	1.406
87		1.455	1.403	1.314	1.253	1.288	1.352		1.135	1.258	1.164	1.556	1.413
88		1.458	1.41	1.316	1.259	1.297	1.353		1.142	1.259	1.169	1.562	1.419
89		1.47	1.41	1.317	1.267	1.303	1.353	1.123	1.144	1.26	1.173	1.559	1.419
90		1.467	1.41	1.319	1.269	1.315	1.362	1.133	1.142	1.258	1.178	1.56	1.422
91		1.464	1.413	1.32	1.269	1.324	1.364	1.15	1.148	1.262	1.189	1.565	1.42
92		1.464	1.413	1.32	1.278	1.333	1.365	1.152	1.157	1.26	1.196	1.565	1.427
93		1.467	1.413	1.321	1.287	1.342	1.371	1.158	1.163	1.258	1.208	1.565	1.432
94		1.47	1.413	1.32	1.294		1.363	1.166	1.164	1.259	1.215	1.572	1.438
95		1.477	1.416	1.32	1.304		1.369	1.159	1.173	1.265	1.218	1.573	1.441
96		1.477	1.419	1.318	1.305		1.382	1.16	1.181	1.27	1.219	1.572	1.446
97		1.483	1.422	1.316	1.31	1.361	1.394	1.163	1.188	1.279	1.218	1.571	1.446
98		1.483	1.422	1.315	1.318	1.361	1.403	1.167	1.194		1.227	1.587	1.448
99		1.489	1.431	1.311	1.324	1.367	1.407	1.168	1.206	1.289	1.23	1.585	1.452
100		1.501	1.431	1.309	1.332	1.373	1.41	1.168	1.208	1.301	1.233	1.589	1.449
101		1.507	1.434	1.313	1.334	1.379	1.415	1.175	1.212	1.314	1.236	1.588	1.443
102		1.51	1.437	1.318	1.343	1.382	1.423	1.182	1.22	1.321	1.236	1.589	1.441
103		1.51	1.437	1.317	1.353	1.385	1.427	1.193	1.225	1.321	1.24	1.601	1.456
104		1.525	1.437	1.313	1.346	1.382	1.431	1.188	1.227	1.32	1.239	1.604	1.457
105		1.534	1.44	1.316	1.349	1.382	1.44	1.183	1.231	1.321	1.238	1.603	1.462
106		1.538	1.443	1.318	1.355	1.391	1.445	1.196	1.236	1.323	1.242	1.608	1.473
107		1.553	1.461	1.319	1.354	1.397	1.448	1.197	1.241	1.324	1.244	1.614	1.476
108		1.562	1.477	1.323	1.354	1.4	1.454	1.192	1.248	1.325	1.244	1.609	1.475
109		1.568	1.474	1.324	1.355	1.403	1.459	1.191	1.252	1.331	1.242	1.607	1.477
110		1.571	1.47	1.324	1.356	1.406	1.466	1.198	1.258	1.341	1.243	1.606	1.476
111		1.571	1.464	1.325	1.357	1.41	1.472	1.203	1.267	1.333	1.242	1.622	1.475
112		1.58	1.464	1.327	1.364	1.416	1.468	1.195	1.27	1.341	1.244	1.619	1.478
113		1.589	1.467	1.332	1.372	1.422	1.471	1.208	1.273	1.345	1.244	1.614	1.482
114		1.598	1.464	1.338	1.381	1.428	1.47	1.21	1.276	1.349	1.245	1.617	1.484
115		1.611	1.467	1.342	1.39	1.431	1.477	1.206	1.276	1.36	1.249	1.625	1.484
116		1.617	1.467	1.344	1.411	1.434	1.481	1.218	1.278	1.368	1.26	1.632	1.488
117		1.632	1.47	1.346	1.434	1.437	1.481	1.216	1.277	1.376	1.272	1.637	1.488
118		1.65	1.47	1.348	1.445	1.431	1.482	1.228	1.279	1.383	1.277	1.633	1.493
119		1.656	1.474	1.351	1.457	1.431	1.479	1.239	1.281	1.384	1.294	1.632	1.497
120		1.678	1.48	1.356	1.481	1.434	1.466	1.253	1.284	1.392	1.314	1.634	1.498

121			1.699	1.489	1.362	1.504	1.443	1.458	1.262	1.279	1.394		1.339	1.642	1.508
122			1.714	1.495	1.54	1.539	1.464	1.446	1.281	1.282	1.398		1.355	1.643	1.512
123			1.733	1.501	1.887	1.581	1.483	1.446	1.316	1.279	1.408		1.371	1.662	1.51
124			1.754	1.513	1.912	1.617	1.489	1.449	1.357	1.292	1.409		1.401	1.672	1.518
125			1.775	1.534	1.93	1.655	1.51	1.455	1.394	1.304	1.421		1.44	1.672	1.525
126			1.806	1.583	1.977	1.699	1.531	1.467	1.446	1.323	1.434		1.497	1.673	1.533
127		1.754	1.824	1.586	2.087	1.744	1.553	1.495	1.52	1.348	1.445		1.535	1.677	1.533
128			1.848	1.623	2.264	1.79	1.592	1.536	1.619	1.405	1.454		1.576	1.684	1.531
129			1.87	1.687	2.526	1.842	1.623	1.577	1.731	1.521	1.469		1.626	1.695	1.54
130			1.934	1.778	2.929	1.92	1.666	1.621	1.837	1.663	1.498	2.05	1.655	1.705	1.548
131			1.992	1.922	3.425	2.035	1.723	1.669	1.933	1.795	1.537	2.147	1.693	1.734	1.555
132			2.056	2.132	3.823	2.158	1.8	1.719	2.034	1.887		2.234	1.739	1.789	1.567
133			2.104	2.437	4.014	2.277	1.891	1.761	2.141	1.975		2.297	1.805	1.864	1.593
134		2.592	2.153	2.802	4.107	2.39	2.007	1.791	2.254			2.357	1.888	1.973	1.631
135		2.76	2.193	3.147	4.126	2.52	2.095	1.833	2.391	2.242		2.403		2.066	1.699
136		2.891	2.239	3.436	4.189	2.848	2.175	1.902	2.534	2.447		2.435	2.202	2.171	1.808
137		3.354	2.275	3.674	4.251	2.956	2.22	2.012	2.648	2.681		2.46	2.298	2.31	1.958
138		3.638	2.327	3.845	4.329		2.272	2.188	2.773	2.902		2.484	2.378	2.509	2.142
139		3.967	2.397	3.982	4.425		2.306	2.464	2.952	3.129	1.917	2.511	2.468	2.752	2.329
140			2.534	4.119	4.515	3.684	2.336	2.766	3.151		2.014	2.551	2.594		2.509
141			2.799	4.275	4.626	3.943	2.37	3.023	3.34	3.943	2.158	2.598	2.722		2.674
142		4.262	3.183	4.424	4.741	4.024	2.415	3.252	3.474	4.236	2.418	2.649	2.851	3.935	2.858
143		4.375	3.552	4.555	4.829	4.072	2.495	3.511	3.589	4.638	2.92	2.719	3.03	4.252	3.057
144		4.695	3.839	4.677	4.908	4.116	2.641	3.785		4.877	3.435	2.789	3.193	4.529	3.266
145		4.976	4.098	4.811	5.016	4.205	2.824	4.078		4.879	3.801	2.863	3.339	4.594	3.462
146			4.241	4.909	5.215	4.354	2.988	4.667		4.83	3.942	2.938	3.49	4.692	3.626
147			4.518	5.037	5.376	4.492	3.119	5.418		4.904	4.236	3.036	3.794	4.806	3.72
148			4.835	5.235	5.544	4.639	3.214	5.717	4.158		4.509	3.149	4.179	4.92	3.788
149		6.561	5.101	5.521	5.557	4.84	3.305	5.648	4.338		4.792	3.292	4.298	5.03	3.858
150			5.152	5.759	5.299	5.185	3.412	5.574	4.481	4.419	5.063	3.516	4.125	5.127	4.041
151			5.149	5.811	5.021	5.269	3.522	5.462	4.607	4.18	5.413	3.863	4.008	5.308	4.422
152			5.119	5.832	4.771	4.969	3.613	5.454	4.756	3.957	5.733	4.239	3.922	5.717	4.569
153			5.092	5.789	4.572	4.689	3.756	5.342	4.849	3.758	6.332	4.569	3.861	6.194	4.712
154			5.116	5.793	4.422	4.442	3.933	5.055	4.914	3.593	6.686	4.854	3.661	5.891	4.859
155			5.189	5.692	4.286	4.229	4.092	4.756	4.705	3.44	6.165	5.163	3.428	5.432	5.041
156			5.372	5.387	4.139	4.03	4.272	4.446	4.293	3.329	5.786	5.736	3.199	5.011	5.225
157			5.57	5.061	3.975	3.843	4.512	4.184	3.979	3.256	5.512	6.156	2.946	4.68	5.592
158			5.457	4.805	3.804	3.68	4.793	3.937	3.719	3.224	5.208	5.725	2.686	4.42	5.868
159			5.092	4.604	3.641	3.53	5.128	3.725		3.165	4.935	5.292	2.434	4.201	5.723
160			4.717	4.424	3.475	3.425	5.25	3.531			4.68	4.933	2.214	4.021	5.37
161			4.445	4.272	3.305	3.375	4.863	3.353		3.02		4.611	2.032	3.883	5.068
162			4.235	4.15	-9999	3.361	4.531	3.21		2.908	4.217	4.332	1.869	3.729	4.826
163			4.031	3.997	-9999	3.353	4.235	3.122	2.702	2.801		4.096		3.571	4.618
164			3.82	3.845	2.899	3.355	3.988	3.04	2.607	2.685		3.891	1.961	3.451	4.416
165			3.622	3.723	2.808	3.325	3.787	3.004	2.568	2.582		3.702	1.927	3.351	4.205
166			3.452	3.604	2.746	3.292	3.628	2.949	2.513	2.489		3.53	1.938	3.255	3.994
167			3.318	3.476	2.734	3.21	3.427	2.889	2.42	2.415		3.382		3.177	3.791
168			3.205	3.333	2.719	3.098	3.251	2.839	2.33	2.359		3.258		3.076	3.595
169			3.11	3.208	2.684	3.018	3.098	2.798	2.289	2.292		3.142		2.986	3.432
170			3.013	3.113	2.671	2.978	2.973	2.739	2.274	2.226	3.287	3.006		2.919	3.303
171			2.937	3.031	2.665	2.979	2.863	2.675	2.248	2.153	3.269			2.852	3.177
172			2.903	2.934	2.677	3.036	2.751	2.614	2.206	2.089	3.261			2.801	3.081
173				2.842	2.68	3.171	2.668	2.573	2.177	2.037	3.251			2.781	2.991
174				2.775	2.712	3.26	2.623	2.557	2.169	1.968	3.225			2.757	2.915
175				2.732	2.761	3.24	2.601	2.533	2.139	1.884	3.201		2.561	2.705	2.874
176				2.702	2.758	3.216	2.54	2.531	2.071	1.818	3.159		2.554	2.64	2.831
177				2.656	2.738	3.182	2.485	2.556	1.987	1.811	3.095		2.522	2.588	2.757
178				2.626	2.737	3.131	2.495	2.58	1.913	1.884	3.01		2.515	2.553	2.687
179		3.055	2.879	2.604	2.711	3.108	2.504	2.566	1.853	1.975	2.911		2.532	2.512	2.654
180			2.851	2.586	2.675	3.136	2.501	2.573	1.823	2.039	2.845		2.484	2.418	2.698
181			2.851	2.568	2.648	3.086	2.489	2.598	1.797	2.116	2.821		2.449	2.392	2.807

182		2.891	2.577	2.61	3.007	2.467	2.621	1.791	2.166	2.719		2.446	2.41	2.885
183		2.851	2.595	2.592	2.925	2.489	2.656	1.781	2.174	2.625		2.48	2.431	2.913
184		2.836	2.598	2.606	2.851	2.498	2.683	1.735	2.179	2.55		2.517	2.478	2.926
185		2.815	2.601	2.596	2.775	2.464	2.696	1.673	2.179	2.477		2.564	2.526	2.867
186		2.775	2.681	2.6	2.687	2.406	2.739	1.618	2.208	2.415		2.597	2.612	2.796
187		2.726	2.83	2.646	2.609	2.342	2.799	1.548	2.261	2.362		2.597	2.782	2.725
188		2.717	2.921	2.727	2.551	2.348	2.858	1.497	2.253	2.329		2.586	2.826	2.666
189		2.684	2.988	2.77		2.357	2.929	1.449	2.255			2.585	2.736	2.634
190		2.702	3.034	2.786	2.469	2.37	2.989	1.437	2.23	2.203		2.597	2.665	2.607
191		2.69	3.028	2.812	2.416	2.345	3.04	1.43	2.188	2.135		2.562	2.606	2.606
192		2.659	2.97	2.83	2.362	2.309	3.11	1.398	2.149	2.063		2.515	2.572	2.686
193		2.638	2.882	2.809	2.309	2.263	3.174	1.37	2.107	1.985		2.479		2.725
194		2.629	2.778	2.763	2.246	2.214	3.181	1.377	2.07	1.918		2.442	2.574	2.758
195		2.635	2.674	2.718	2.19	2.162	3.149	1.429	2.002	1.852		2.412	2.602	2.774
196		2.583	2.586	2.684	2.141	2.098	3.106	1.546	1.986	1.823		2.385	2.566	2.793
197		2.51	2.492	2.687	2.101	2.01	3.034	1.499	1.936	1.839		2.338	2.505	2.768
198		2.443	2.412	2.66	2.068	1.909	2.952	1.46	1.873	1.924		2.333	2.513	2.715
199		2.376	2.336	2.603	2.023	1.824	2.874	1.441	1.793	1.966		2.389	2.521	2.636
200		2.345	2.303	2.564	2.006	1.757	2.808	1.418	1.735	1.978		2.433	2.525	2.585
201		2.37	2.29	2.556	1.972	1.69	2.75	1.402	1.816	1.984		2.495	2.561	2.536
202		2.351	2.266	2.56	1.925	1.702	2.678	1.41	1.811	1.969		2.532	2.529	2.487
203		2.312	2.281	2.581	1.893	1.702	2.625	1.393	1.776	1.971	1.698	2.556	2.507	2.457
204		2.3	2.284	2.605	1.904	1.733	2.585	1.386	1.762	1.974	1.652	2.535	2.46	2.433
205		2.342	2.248	2.628	1.9	1.72	2.562	1.367	1.761	2.002	1.6	2.492	2.415	2.435
206		2.418	2.196	2.639	1.879	1.684	2.521	1.368	1.767	2.045	1.553	2.431	2.378	2.457
207		2.543	2.168	2.626	1.88	1.644	2.476	1.447	1.798	1.972	1.56	2.363	2.327	2.483
208		2.699	2.15	2.592	1.905	1.632	2.452	1.737	1.817	2.043	1.591	2.308	2.304	2.524
209		2.815	2.229	2.529	1.948	1.629	2.405	1.767	1.766	2.143	1.519	2.316	2.34	2.517
210		2.912	2.251	2.458	2.037	1.638	2.379	1.823	1.791	1.992	1.451	2.31	2.296	2.498
211		2.93	2.232	2.389	2.115	1.714	2.341	1.796	1.842	1.861	1.401	2.239	2.267	2.471
212	2.077	2.888	2.22	2.332	2.163	1.699	2.312	1.745	1.832	1.741	1.366	2.197	2.218	2.465
213	2.007	2.812	2.193	2.322	2.187	1.717	2.296	1.721	1.831	1.704	1.342	2.209	2.179	2.436
214	1.94	2.751	2.162	2.278	2.182	1.751	2.283	1.784	1.991	1.702	1.348	2.225	2.141	2.4
215	1.882	2.638	2.092	2.245	2.16	1.699	2.293	1.78	2.425	1.724	1.445	2.232	2.104	2.356
216	1.839	2.531	2.013	2.206	2.138	1.663	2.335	1.76	2.33	1.812	1.578	2.234	2.083	2.313
217	1.787	2.437	1.937	2.192	2.086	1.647	2.394	1.854	2.116	1.799	1.567	2.204	2.095	2.239
218	1.72	2.379	1.922	2.204	2.022	1.626	2.364	1.886	1.966	1.797	1.579	2.148	2.037	2.17
219	1.772	2.37	1.934	2.194	1.963	1.592		1.874	1.907	1.748	1.651	2.094	1.934	2.165
220	1.882	2.425	1.885	2.18	1.911	1.583	2.281	1.894	1.832	1.688	1.705	2.05	1.835	2.142
221	1.858	2.613	1.855	2.17	1.876	1.519	2.25	1.929	1.782	1.704	1.798	1.96	1.827	2.092
222	1.873	2.781	1.952	2.126	1.834	1.464	2.237	1.925	1.846	1.778	1.865	1.908	1.832	2.096
223	1.94	2.912	2.095	2.062	1.783	1.452	2.214	1.869	1.75	1.708	1.862	2.053	1.828	2.154
224	1.998	3.034	2.089	2.022	1.742	1.522	2.188	1.794	1.649	1.669	1.813		1.79	2.201
225	2.074	3.11	2.062	2.051	1.717	1.556	2.159	1.722	1.549	1.582	1.762		1.737	2.196
226	2.293	3.138	2.065	2.152	1.68	1.602	2.111	1.638	1.507	1.519	1.736		1.685	2.217
227	2.293	3.119	2.086	2.126	1.628	1.586	2.059	1.595	1.485	1.55	1.703		1.626	2.176
228	2.184	3.083	2.108	2.104	1.636	1.513	2.017	1.573	1.499	1.606	1.648		1.71	2.167
229	2.077	3.055	2.156	2.115	1.654	1.428	2.007	1.506	1.765	1.841	1.585		1.752	2.244
230	2.022	3.092	2.211	2.167	1.61	1.385	1.963	1.455	1.598	2.132	1.514		1.699	2.298
231	1.979	3.238	2.159	2.16	1.563	1.364	1.917	1.48	1.532	2.171	1.47	2.204	1.651	2.322
232	1.879	3.418	2.077	2.162	1.512	1.321	1.837	1.501	1.51	2.211	1.492	2.207	1.608	2.347
233	1.772	3.43	2.007	2.129	1.466	1.422	1.825	1.527	1.487	2.305		2.202	1.566	2.316
234	1.821	3.351	1.946	2.09	1.467	1.489	1.815	1.554	1.586	2.381		2.172	1.541	2.433
235	1.876	3.244	1.891	2.232	1.484	1.534	1.786	1.573	1.555	2.275		2.085	1.562	2.73
236	1.882	3.135	1.818	2.166	1.474	1.711	1.727	1.587	1.416	2.135		2.015	1.562	2.599
237	1.873	3.013	1.745	2.109	1.471	1.635	1.651	1.601	1.34	2.001	1.635	1.99	1.542	2.465
238	1.888	2.894	1.702	2.017	1.686	1.623	1.636	1.598	1.322	1.881	1.609	1.968	1.526	2.351
239	1.931	2.775	1.9	1.937	2.244	1.614	1.622	1.574	1.29	1.814	1.605	2.34	1.519	2.268
240	1.943	2.671	2.007	1.902	2.311	1.516	1.614	1.556	1.31	1.795	1.59	2.436	1.505	2.208
241	1.949	2.589	1.897	1.922	2.15	1.452	1.621	1.577	1.366	1.748	1.591		1.533	2.129
242	1.946	2.489	1.827	1.99	1.911	1.41	1.611	1.624	1.37	1.697	1.65		1.573	2.03
243	1.961	2.406	1.751	2.083	1.759	1.376	1.596	1.658	1.796	1.638	1.676		1.612	1.968

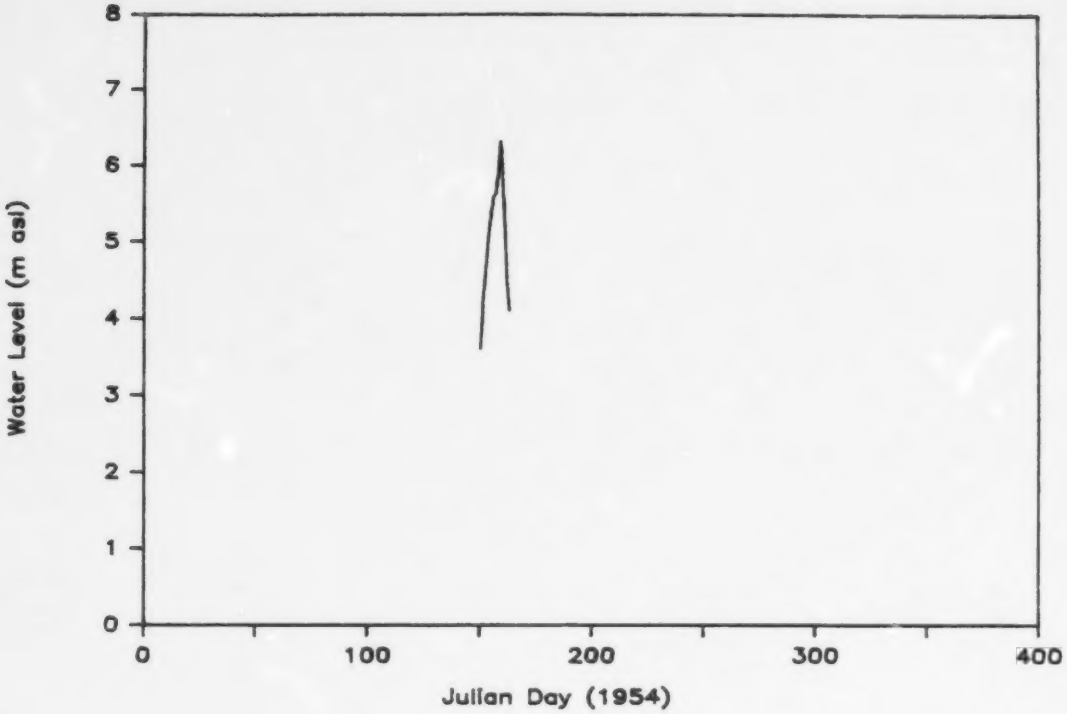
244	1.986	2.367	1.751	2.165	1.765	1.346	1.597	1.693	2.068	1.612	1.626		1.576	1.925
245	2.001	2.36	1.781	2.258	1.663	1.33	1.589	1.69	1.866	1.574	1.769		1.537	1.872
246	2.016	2.425	1.739	2.335	1.548	1.275	1.579	1.63	1.59	1.509	1.755		1.509	1.852
247	2.004	2.44	1.705	2.34	1.49	1.196	1.625	1.521	1.378	1.424	1.686		1.528	1.857
248	1.995	2.348	1.699	2.323	1.458	1.153	1.697	1.507	1.271	1.386	1.739		1.584	1.85
249	1.976	2.251	1.678	2.342	1.4	1.096	1.699	1.547	1.16	1.335	1.699		1.645	1.825
250	1.937	2.159	1.696	2.275	1.368	1.068	1.622	1.469	1.038	1.311	1.602		1.647	1.759
251	1.894	2.08	1.69	2.174	1.492	1.083	1.551	1.48	1.052	1.332	1.607		1.639	1.705
252	1.842	2.019	1.611	2.081	1.575	1.083	1.545	1.427	1.086	1.295	1.578		1.72	1.71
253	1.778	1.961	1.544	2.018	1.475	1.108	1.53	1.368	1.088	1.244	1.554		1.718	1.733
254	1.72	1.912	1.507	1.971	1.415	1.172	1.464	1.374	1.109	1.22	1.518		1.672	1.656
255	1.693	1.879	1.51	1.9	1.349	1.147	1.434	1.313	1.111	1.199	1.478		1.609	1.595
256	1.653	1.836	1.507	1.812	1.276	1.111	1.444	1.212	1.081	1.152	1.471		1.549	1.633
257	1.669	1.781	1.483	1.738	1.21	1.111	1.378	1.102	1.08	1.244	1.446		1.54	1.622
258	1.69	1.73	1.492		1.233	1.211	1.339	0.99	1.059	1.319	1.634		1.674	1.505
259	1.663	1.675	1.492	1.671	1.314	1.385	1.322	1.065	1.284	1.375	1.687		1.809	1.412
260	1.608	1.623	1.47	1.692	1.319	1.666	1.428	1.614	1.484	1.67	1.576		2.027	1.427
261	1.608	1.571	1.449	1.714	1.272	1.483	1.462	1.528	1.322	1.608	1.528		2.228	1.441
262	1.626	1.538	1.48	1.704	1.224	1.324	1.435	1.387	1.434	1.504	1.441		2.053	1.435
263	1.632	1.495	1.559	1.661	1.208	1.227	1.458	1.391	1.669	1.423	1.349		1.97	1.424
264	1.644	1.474	1.534	1.639	1.444	1.153	1.479	1.383	1.453	1.377	1.34		1.882	1.655
265	1.629	1.531	1.489	1.598	1.426	1.096	1.488	1.318	1.292	1.298	1.503		1.844	1.598
266	1.614	1.544	1.507	1.566	1.322	1.062	1.483	1.208	1.177	1.234	1.724		1.794	1.628
267	1.626	1.498	1.534	1.597	1.182	1.025	1.459	1.121	1.139	1.246	1.712		1.731	1.689
268	1.602	1.431	1.659	1.608	1.236	0.995	1.479	1.109	1.149	1.251	1.775		1.704	1.747
269	1.605	1.391	1.714	1.569	1.298	1.013	1.428	1.313	1.106	1.201	1.656	1.529	1.713	1.625
270	1.626	1.355	1.574	1.531	1.33	1.019	1.354	1.209	1.104	1.207	1.53	1.493	1.683	1.517
271	1.617	1.333	1.47	1.524	1.311	1.138	1.326	1.139	1.286	1.241	1.442	1.48	1.72	1.459
272	1.611	1.312	1.376	1.486	1.395	1.269	1.29	1.111	1.61	1.226	1.372	1.51	1.757	1.384
273	1.58	1.406	1.309	1.501	1.414	1.37	1.214	1.095	1.559	1.176	1.301	1.475	1.754	1.283
274	1.489	1.403	1.297	1.562	1.379	1.516	1.138	1.161	1.572	1.145	1.273	1.374	1.728	1.184
275	1.562	1.437	1.285	1.549	1.323	1.641	1.102	1.223	1.837	1.124	1.268	1.271	1.685	1.371
276	1.653	1.44	1.245	1.469	1.252	1.455	1.059	1.184	1.74	1.405	1.299	1.2	1.644	1.34
277	1.559	1.4	1.217	1.351	1.231	1.263	1.048	1.176	1.801		1.307	1.16	1.576	1.264
278	1.44	1.394	1.205	1.327	1.328	1.105	1.03	1.177	2.025		1.263	1.155	1.577	1.642
279	1.349	1.391	1.208	1.335	1.319	1.01	1.02	1.176	1.821		1.291	1.151	1.554	1.887
280	1.358	1.364	1.227	1.312	1.194	0.949	1.033		1.707		1.426	1.098	1.515	1.764
281	1.425	1.336	1.3	1.29	1.07	0.864	1.051		1.575		1.516	1.067	1.557	1.708
282	1.339	1.336	1.327	1.278	1.128	0.858	1.034	1.196	1.463		1.429	1.135	1.568	1.671
283	1.288	1.388	1.282	1.238	1.112	0.916	1.045	1.253	1.364		1.372	1.131	1.503	1.605
284	1.269	1.464	1.376	1.314	1.012	0.897	1.047	1.198	1.249		1.322	1.151	1.413	1.635
285	1.272	1.577	1.33	1.404	0.97	0.931	1.027	1.095	1.144		1.315	1.193	1.339	1.741
286	1.333	1.635	1.339	1.389	0.982	1.004	1.055	1.086	1.091		1.302	1.201	1.305	1.657
287	1.33	1.602	1.376	1.349	0.976	0.989	1.149	1.103	1.059	1.688	1.265	1.259	1.339	1.592
288	1.272	1.574	1.346	1.309	0.994	0.974	1.253	1.076	1.051	1.548	1.219	1.323	1.401	1.581
289	1.211	1.568	1.33	1.34	1.051	0.955	1.317	1.037	1.036	1.482	1.179	1.249	1.41	1.579
290	1.175	1.568	1.321	1.321	1.055	0.946	1.35	1.057	0.977	1.429	1.181	1.25	1.516	1.574
291	1.181	1.565	1.303	1.261	1.04	0.937	1.23	1.137	0.971	1.365	1.203	1.202	1.534	1.585
292	1.16	1.55	1.294	1.293	1.034	0.955	1.135	1.153	1.001	1.335	1.223	1.182	1.536	1.619
293	1.126	1.528	1.315	1.337	1.029	1.025	1.086	1.231	1.016	1.381	1.245	1.277	1.548	1.649
294	1.15	1.516	1.403	1.283	1.023	1.05	1.063	1.251	0.98	1.567	1.237	1.309	1.503	1.695
295	1.193	1.534	1.495	1.247	1.022	1.041	1.056	1.221	0.932	1.621	1.194	1.292	1.434	1.717
296	1.272	1.568	1.528	1.245	1.068	1.041	1.061	1.174	0.966	1.589	1.162	1.282	1.409	1.724
297	1.333	1.595	1.562	1.272	1.131	1.032	1.063	1.115	0.978	1.569	1.122	1.304	1.429	1.719
298	1.394	1.617	1.602	1.317	1.171	1.004	1.047	1.039	1.013	1.568	1.058	1.305	1.476	1.713
299	1.406	1.632	1.659	1.324	1.229	0.98	1.062	0.978	1.017	1.564		1.414	1.427	1.739
300	1.394	1.635	1.702	1.332	1.316	0.937	1.06	0.966	1.005	1.513		1.483	1.349	1.785
301	1.397	1.638	1.672	1.355	1.302	0.885	1.047	0.992	1.017	1.45		1.503	1.285	1.796
302	1.4	1.632	1.629	1.388	1.261	0.858	1.042	0.998	1.038	1.385		1.459	1.22	1.792
303	1.397	1.608	1.598	1.423	1.248	0.867	1.03	1.068	1.033	1.317			1.161	1.772
304	1.388	1.583	1.55	1.406	1.243	0.934	1.028	1.091	1.03	1.22		1.329	1.119	1.736

305	1.37	1.553	1.489	1.326	1.265	0.922	1.072	1.025	1.029	1.123	1.268	1.085	1.706
306	1.358	1.519	1.428	1.245	1.343	0.897	1.085	0.977	1.004	1.047	1.206	1.049	1.699
307	1.349	1.507	1.367	1.169	1.362	0.873	1.087	0.991	0.947	0.988	1.174	1.026	1.676
308	1.346	1.51	1.3	1.116	1.335	0.849	1.09	0.972	0.867	0.958	1.142	0.996	1.611
309	1.333	1.516	1.221	1.075	1.316	0.84	1.077	0.948	0.807	0.933	1.086	0.968	1.53
310	1.303	1.516	1.144	1.034	1.304	0.873	1.053	0.975	0.786		1.015	0.951	1.454
311	1.272	1.519	1.071	0.995	1.306	0.971	1.029	1.017	0.758		0.944	0.928	1.363
312	1.275	1.531	1.01	0.962	1.274	0.983	1.066	1.003	0.718		0.894	0.914	1.251
313	1.248	1.556	0.968	0.911	1.224	0.925	1.128	0.939	0.676		0.847	0.911	1.141
314	1.196	1.574	0.928	0.854	1.178	0.894	1.186	0.907	0.621		0.797	0.917	1.051
315	1.211	1.589	0.91	0.833	1.14	0.894	1.17	0.902	0.566		0.752	0.936	0.967
316	1.306	1.598	0.907	0.842	1.118	0.928	1.135	0.895	0.507		0.73	1.038	0.891
317	1.263	1.605	0.922	0.883	1.088	1.013	1.127	0.836	0.46		0.717	1.222	0.833
318	1.202	1.617	0.916	0.879	1.058	1.053	1.149	0.778	0.429		0.699	1.262	0.779
319	1.105	1.626	0.894	0.906	1.021	1.019	1.154	0.773	0.423		0.694	1.218	0.747
320	1.016	1.638	0.858	0.962	0.978	0.961	1.138	0.746	0.451		0.668	1.162	0.733
321	0.946	1.638	0.821	0.982	0.916	0.922	1.135	0.708	0.508		0.637	1.14	0.718
322	0.891	1.638	0.785	0.999	0.842	0.885	1.122	0.675	0.572		0.604	1.147	0.736
323	0.858	1.626	0.76	1.029	0.766	0.867	1.077	0.632	0.606		0.585	1.131	0.789
324	0.83	1.611	0.73	1.053	0.688	0.879	1.025	0.594	0.695		0.597	1.107	0.797
325	0.815	1.592	0.705	1.058	0.623	0.901	0.962	0.578	0.719		0.626	1.053	0.797
326	0.806	1.574	0.69	1.063	0.552	0.94	0.89	0.571	0.72		0.669	1.025	0.79
327	0.788	1.562	0.693	1.076	0.502	0.989	0.847	0.589	0.739		0.756	1.023	0.776
328	0.788	1.534	0.727	1.1	0.558	0.949	0.784	0.602	0.765		0.848	0.989	0.769
329	0.8	1.513	0.766	1.127	0.607	0.876	0.734	0.604	0.772		0.879	0.911	0.761
330	0.815	1.483	0.785	1.135	0.585	0.788	0.719	0.621	0.764		0.893	0.844	0.755
331	0.821	1.446	0.797	1.145	0.577	0.702	0.714	0.62	0.745		0.908	0.794	0.73
332	0.806	1.41	0.812	1.151	0.571	0.62	0.714	0.599	0.733		0.933	0.748	0.712
333	0.779	1.373	0.846	1.144	0.558	0.571	0.697	0.548	0.73		0.962	0.716	0.724
334	0.763	1.333	0.861	1.13	0.53	0.58	0.719	0.472	0.742		0.988	0.719	0.735
335	0.751	1.297	0.873	1.166	0.53	0.648	0.745	0.399	0.761		1.011	0.769	0.712
336	0.715	1.248	0.934	1.158	0.578	0.693	0.761	0.34	0.794		1.037	0.788	0.706
337	0.675	1.208	0.94	1.128	0.598	0.751	0.769	0.301	0.782		1.056	0.783	0.721
338	0.66	1.172	0.937	1.09	0.58	0.748	0.763	0.289	0.75		1.075	0.782	0.735
339	0.654	1.132	0.943	1.052	0.567	0.736	0.811	0.387	0.74		1.081	0.786	0.729
340	0.654	1.096	0.952	1.003	0.595	0.739	0.976	0.455	0.738		1.092	0.809	0.731
341	0.651	1.062	0.958	0.954	0.613	0.739	0.971	0.441	0.718		1.113	0.819	0.792
342	0.657	1.032	0.955	0.907	0.611	0.751	0.899	0.497	0.681		1.135	0.834	0.875
343	0.672	1.007	0.952	0.87	0.619	0.742	0.844	0.459	0.656		1.137	0.843	0.926
344	0.687	0.989	0.94	0.829	0.697	0.736	0.819	0.438	0.661		1.143	0.88	0.949
345	0.702	0.98	0.928	0.782	0.766	0.739	0.817	0.452	0.685		1.151	0.891	0.962
346	0.724	0.971	0.928	0.74	0.78	0.754	0.812	0.465	0.692		1.158	0.9	1.012
347	0.763	0.974	0.928	0.704	0.781	0.797	0.796	0.474	0.691		1.174	0.928	1.056
348	0.794	0.986		0.676	0.769	0.87	0.801	0.476	0.687		1.196	0.946	1.093
349	0.8	0.983		0.645	0.782	0.922	0.845	0.509	0.692		1.212	0.963	1.118
350	0.812	0.986		0.629	0.791	0.925	0.91	0.575	0.719		1.217	0.971	1.126
351	0.824	0.992	1.029	0.618	0.788	0.891	0.844	0.623	0.732		1.225	0.975	1.132
352	0.84	0.998	1.077	0.589	0.788	0.928	0.793	0.631	0.752		1.256	0.994	1.141
353	0.861	0.992	1.102	0.58	0.788	1.004	0.773	0.623	0.795		1.287	1.011	1.151
354	0.888	0.971	1.108	0.577	0.796	1.007	0.733	0.623	0.865		1.293	1.039	1.171
355	0.919	0.952	1.108	0.592	0.832	1.004	0.675	0.621	0.913		1.313	1.067	1.18
356	0.943	0.934	1.102	0.597	0.87	0.995	0.621	0.633	0.913		1.31	1.074	1.18
357	0.965	0.925	1.111	0.607	0.886	0.995	0.573	0.645	0.908		1.3	1.081	1.177
358	0.989	0.928	1.114	0.615	0.897	1.004	0.544	0.658	0.897		1.294	1.096	1.17
359	1.004	0.937	1.12	0.638	0.912	1.01	0.566	0.674	0.91		1.298	1.119	1.167
360	1.022	0.949	1.129	0.662	0.926	1.013	0.609	0.681	0.931		1.288	1.125	1.173
361	1.035	0.961	1.144	0.701	0.944	1.016	0.611	0.692	0.934		1.29	1.129	1.179
362	1.041	0.983	1.153	0.728	0.978	1.01	0.564	0.699	0.928		1.298	1.145	1.181
363	1.053	1.001	1.169	0.743	0.984	1.001	0.526	0.707	0.925		1.305	1.152	1.179
364	1.077	1.019	1.175	0.76	0.959	0.995	0.503	0.722	0.918		1.311	1.157	1.165
365	1.093	1.044	1.178	0.77	0.95	1.001	0.502	0.746	0.918		1.311		1.164
366				0.778				0.755			1.308		

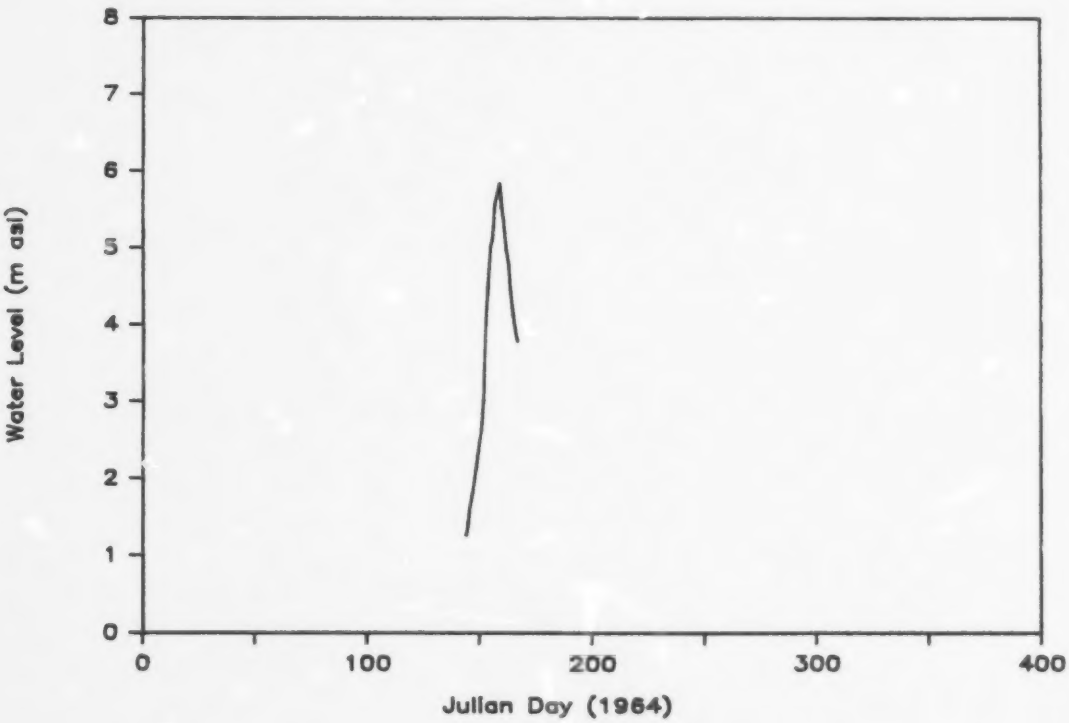
· All data from Water Survey of Canada

A3. Annual hydrographs.

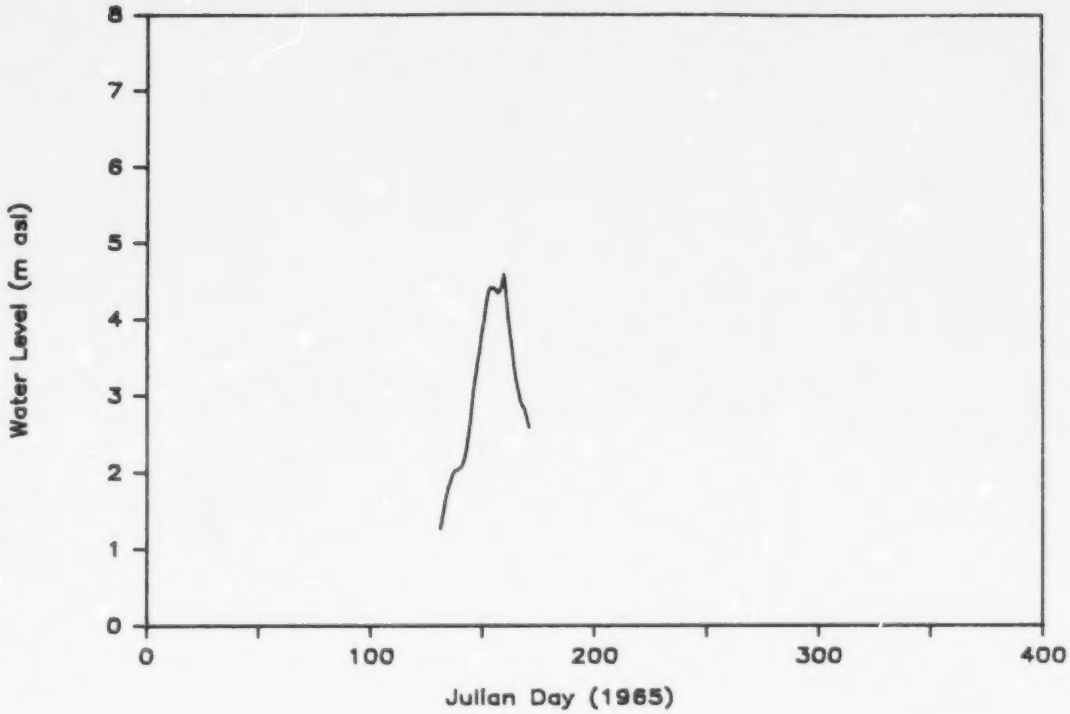
East Channel at Inuvik (Brown)



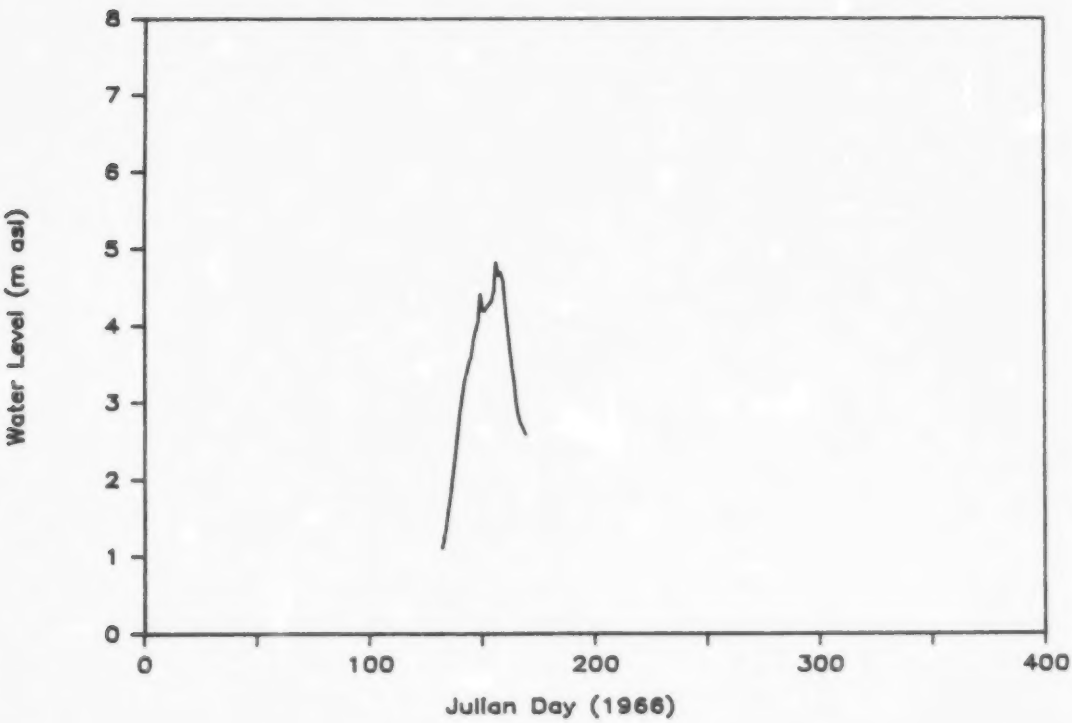
East Channel at Inuvik (IRL)



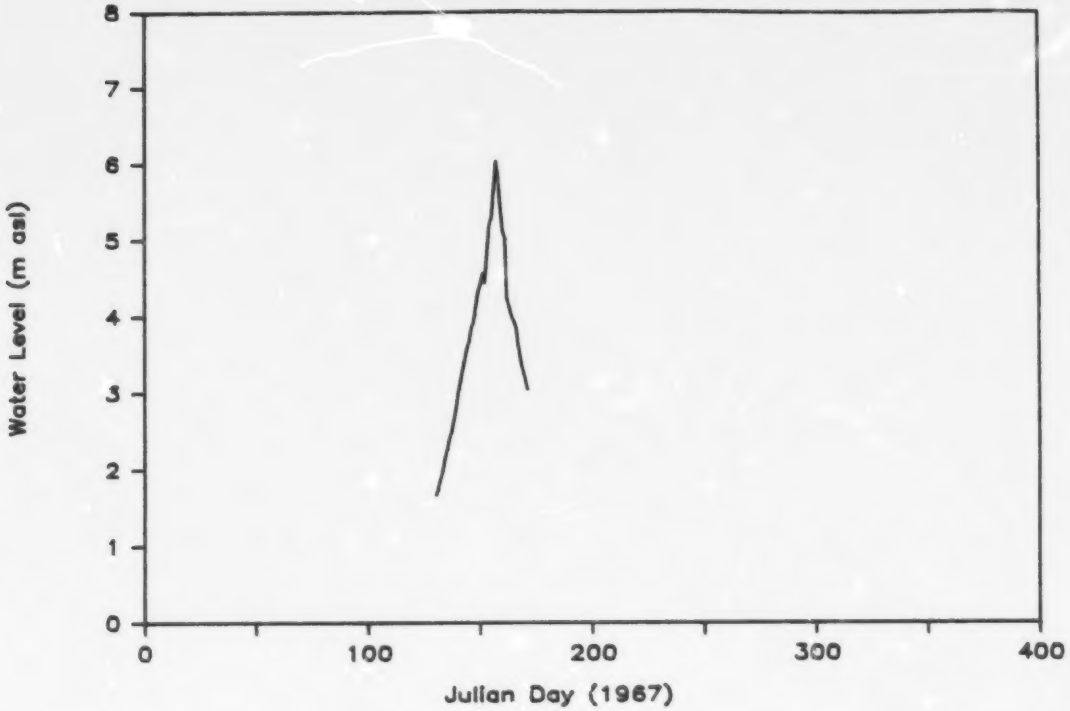
East Channel at Inuvik (IRL)



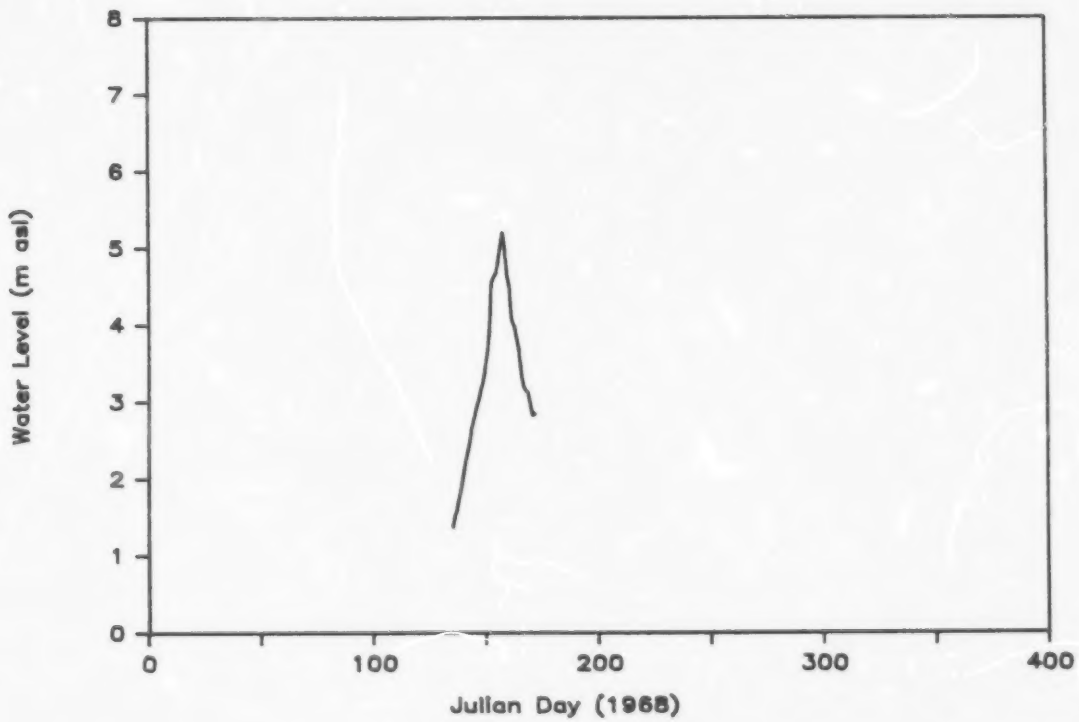
East Channel at Inuvik (IRL)



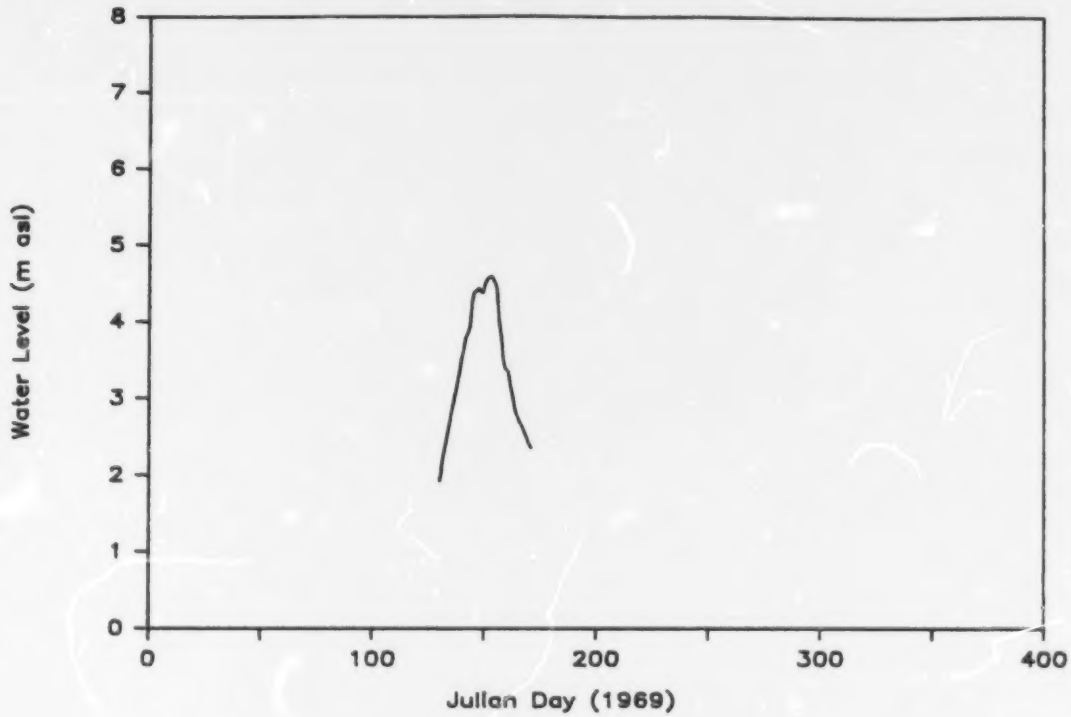
East Channel at Inuvik (IRL)



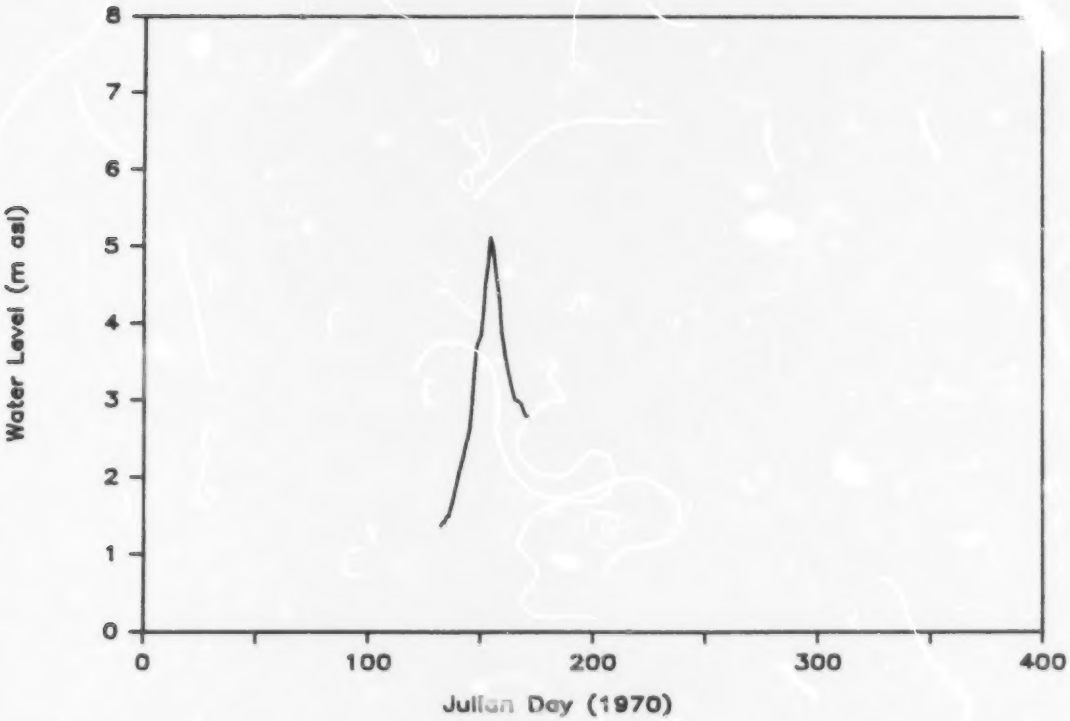
East Channel at Inuvik (IRL)

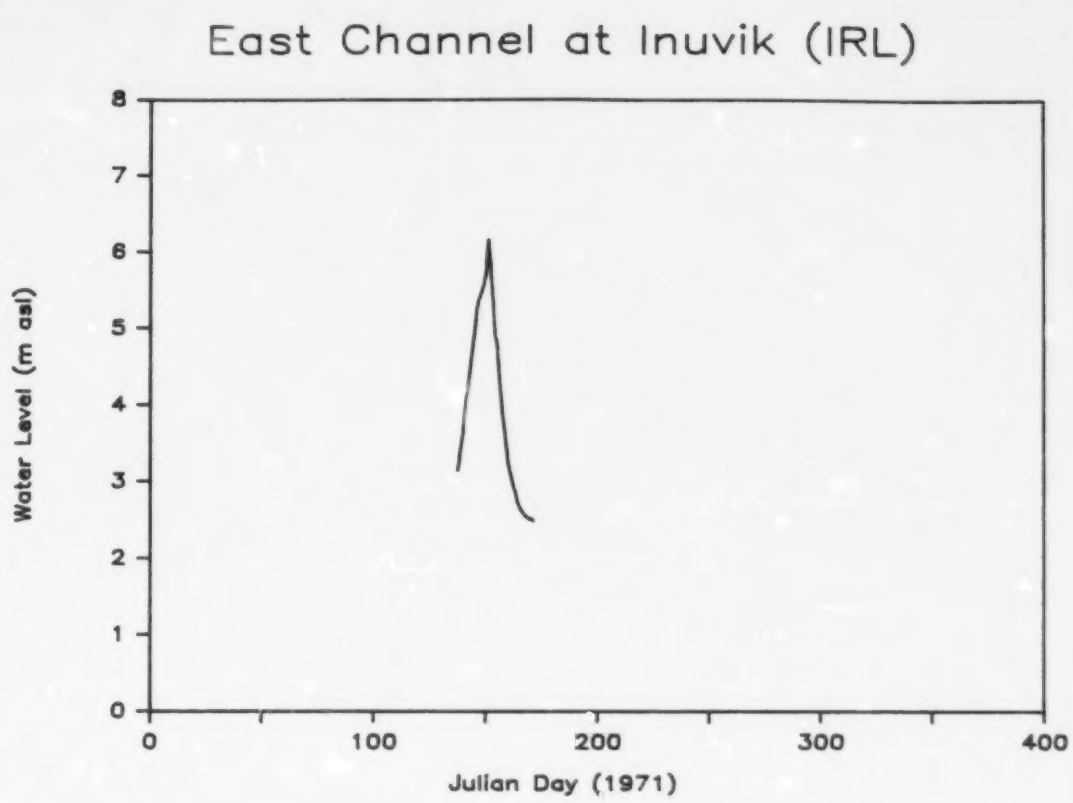


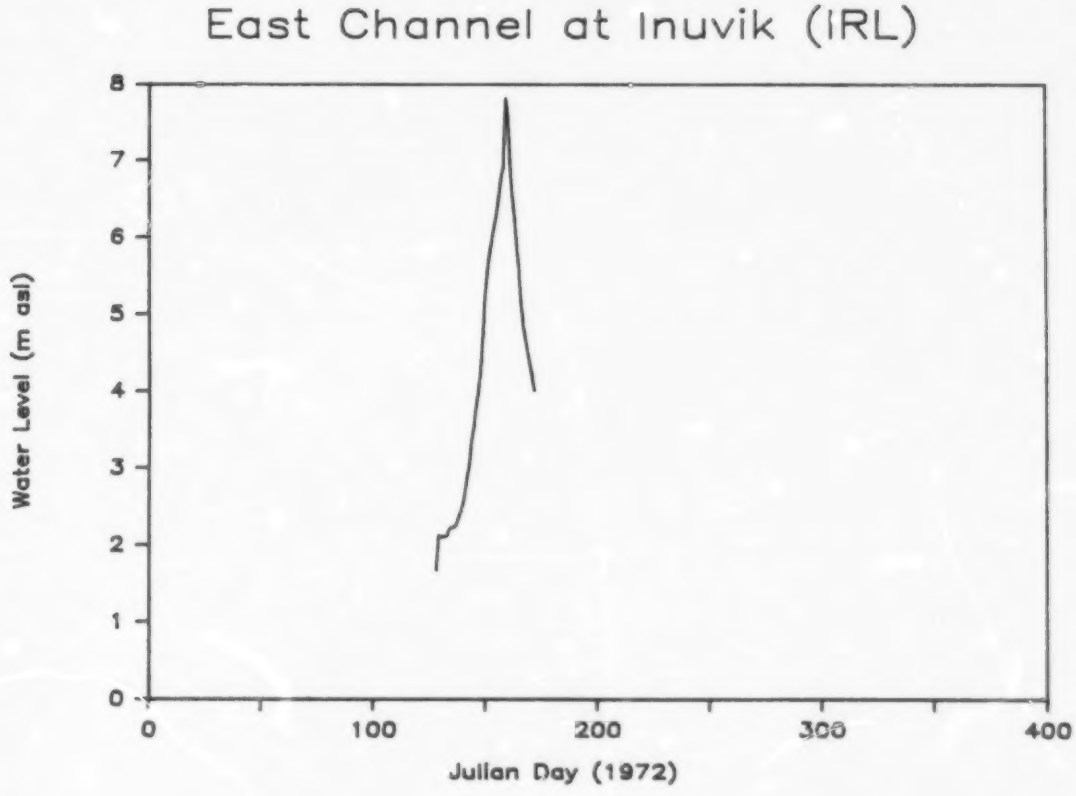
East Channel at Inuvik (IRL)



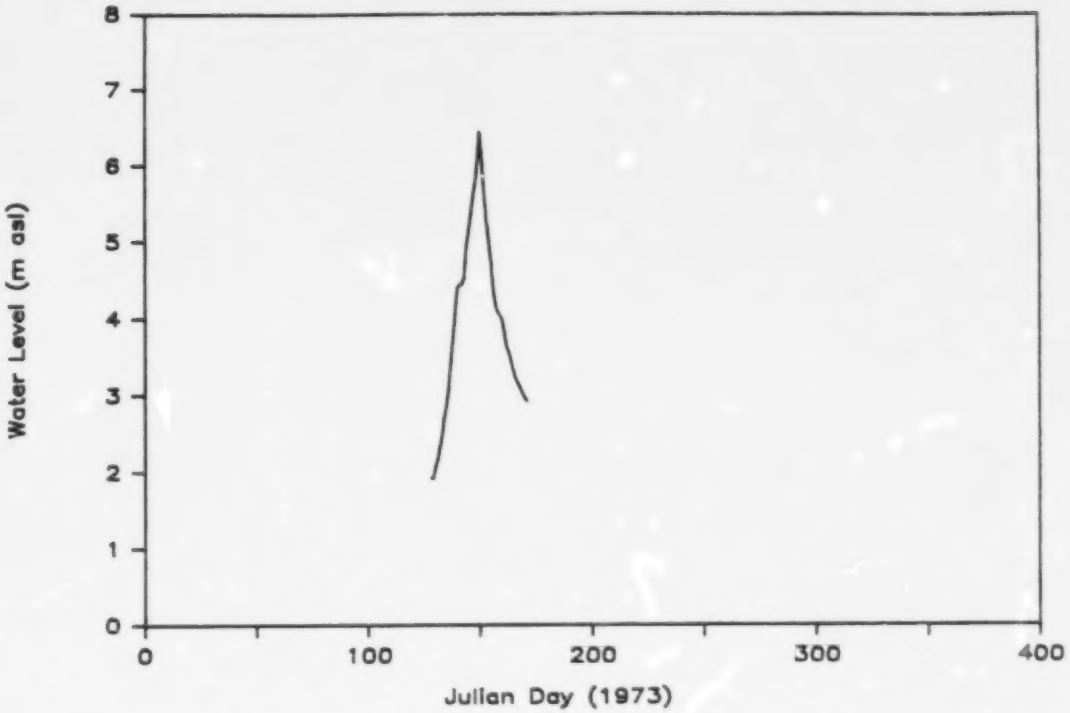
East Channel at Inuvik (IRL)



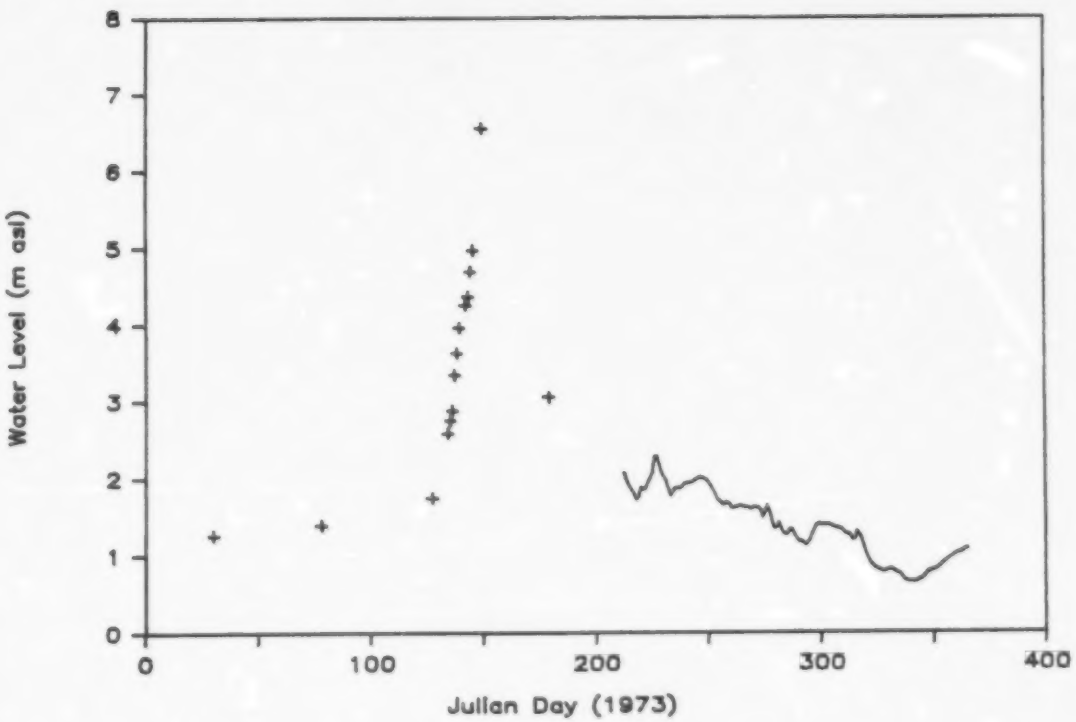

East Channel at Inuvik (IRL)
Water Level (m asl)
0
1
2
3
4
5
6
7
8
0
100
200
300
400
Julian Day (1971)


East Channel at Inuvik (IRL)
Water Level (m asl)
0
1
2
3
4
5
6
7
8
0
100
200
300
400
Julian Day (1972)

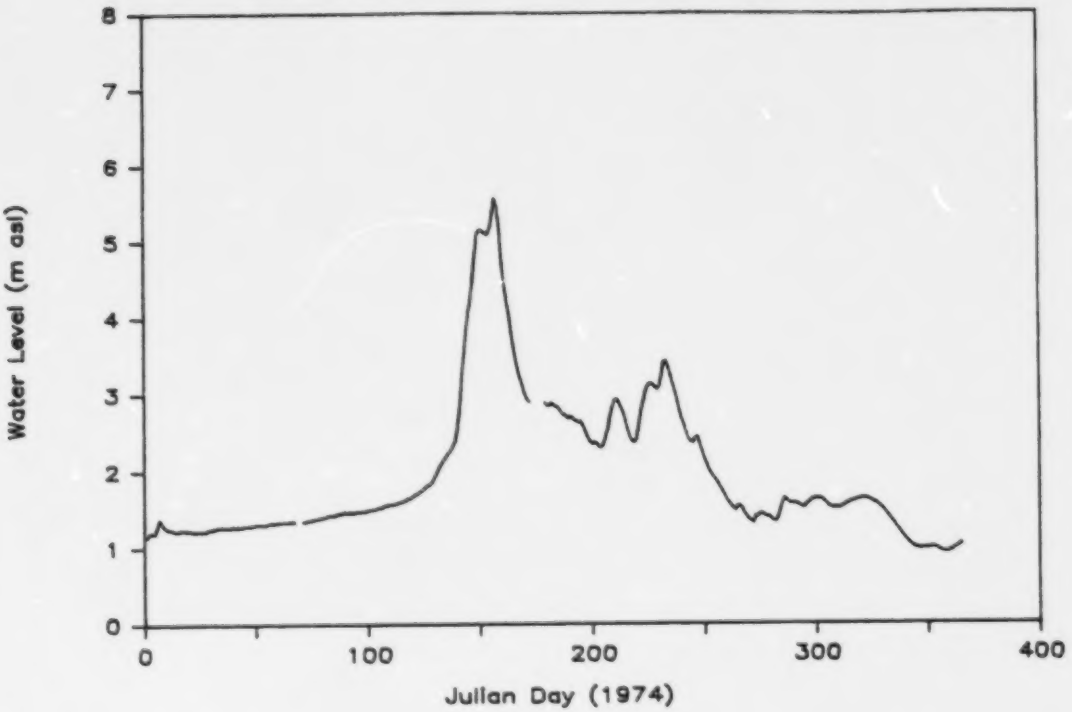
East Channel at Inuvik (IRL)



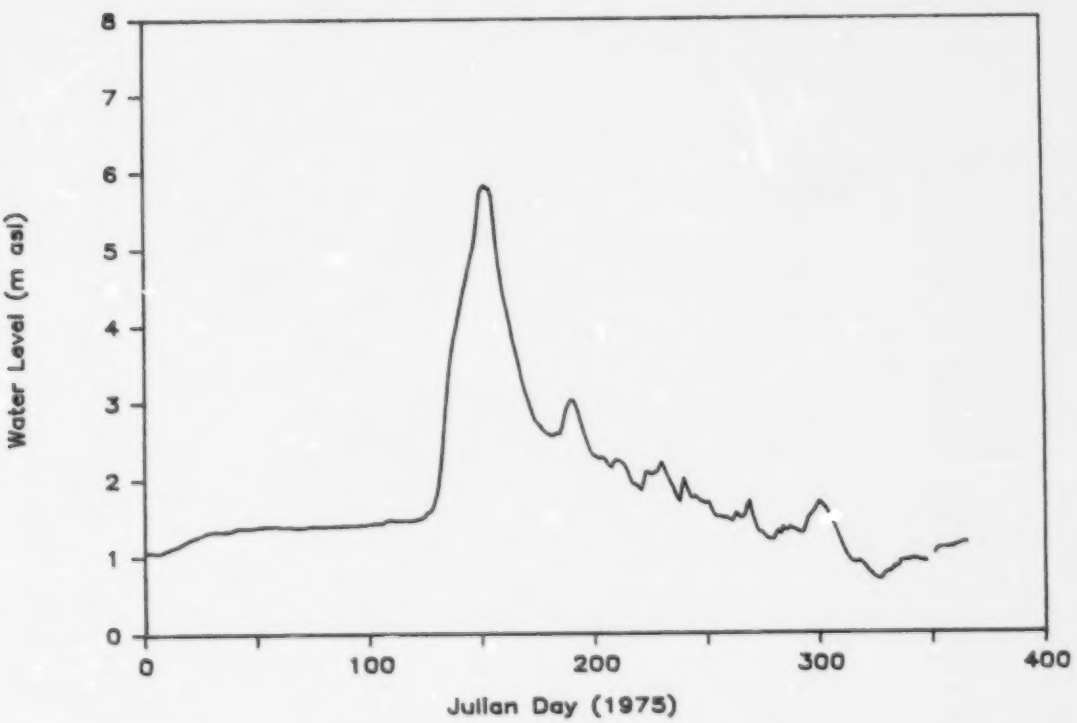
East Channel at Inuvik (WSC)



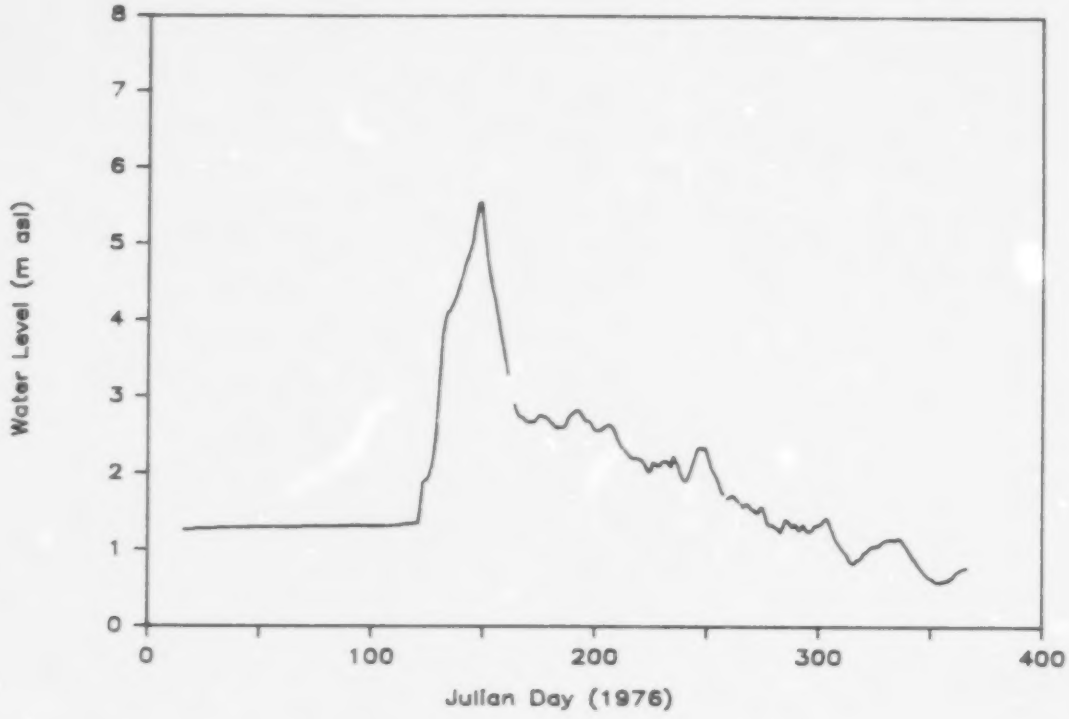
East Channel at Inuvik (WSC)



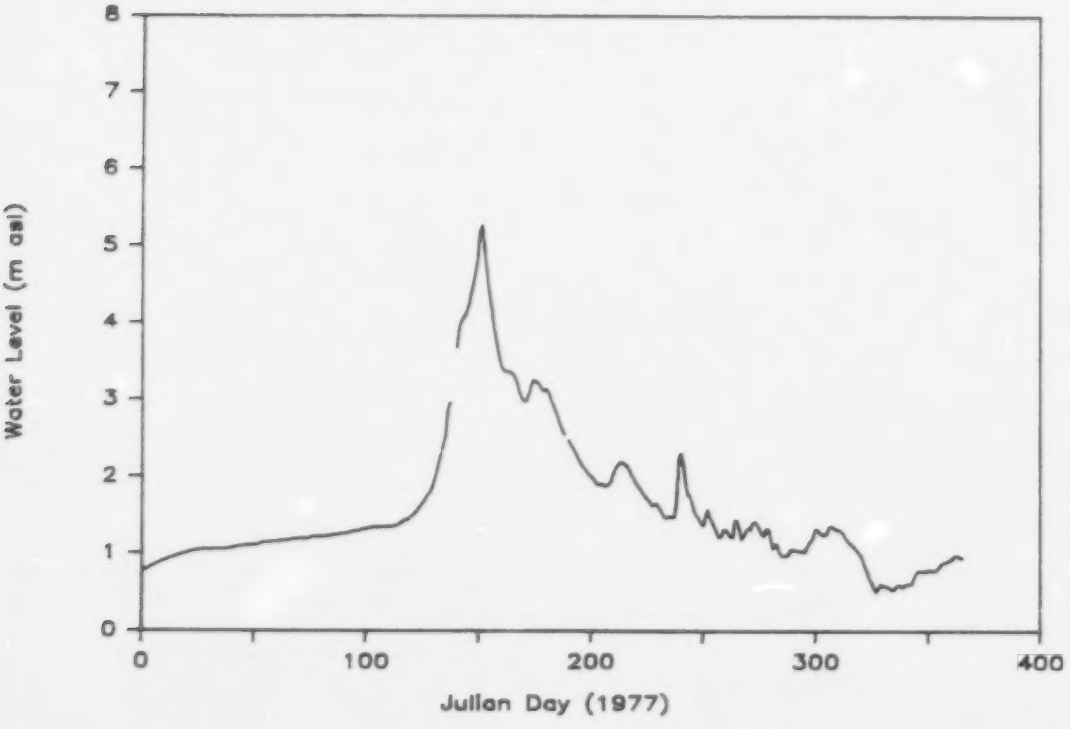
East Channel at Inuvik (WSC)



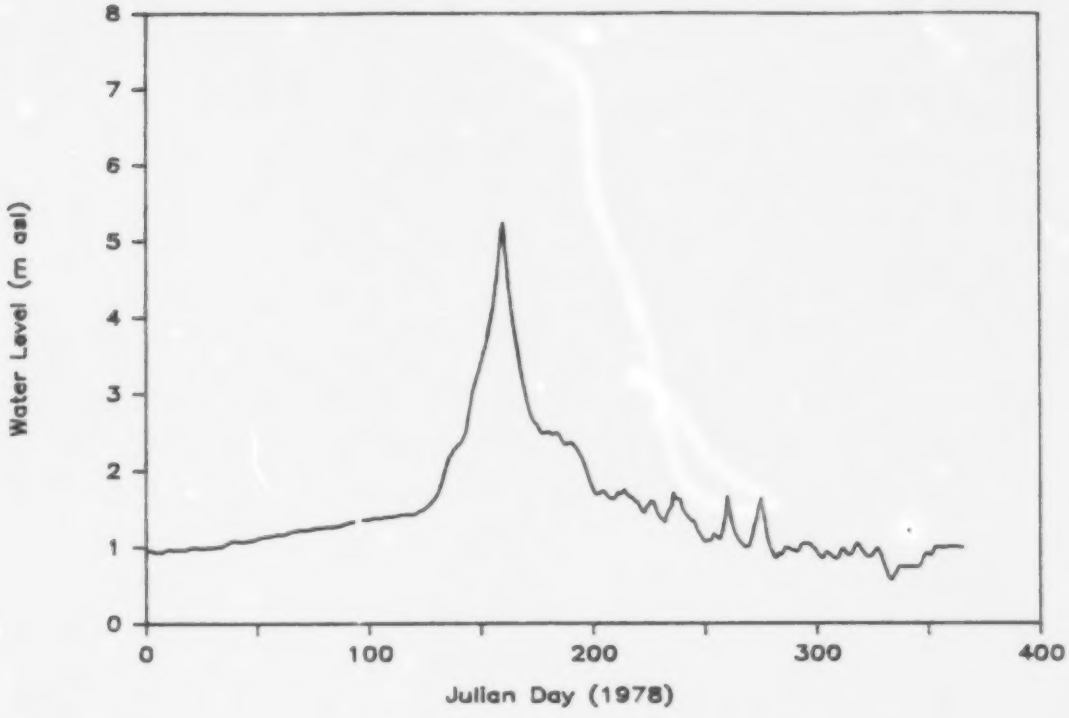
East Channel at Inuvik (WSC)



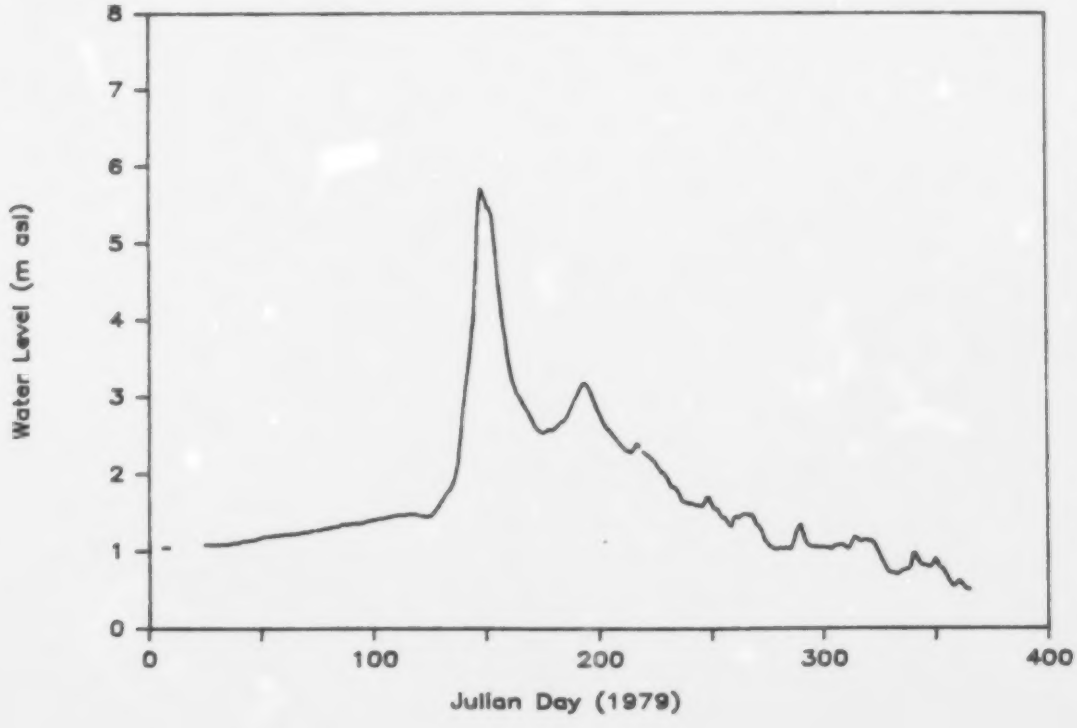
East Channel at Inuvik (WSC)



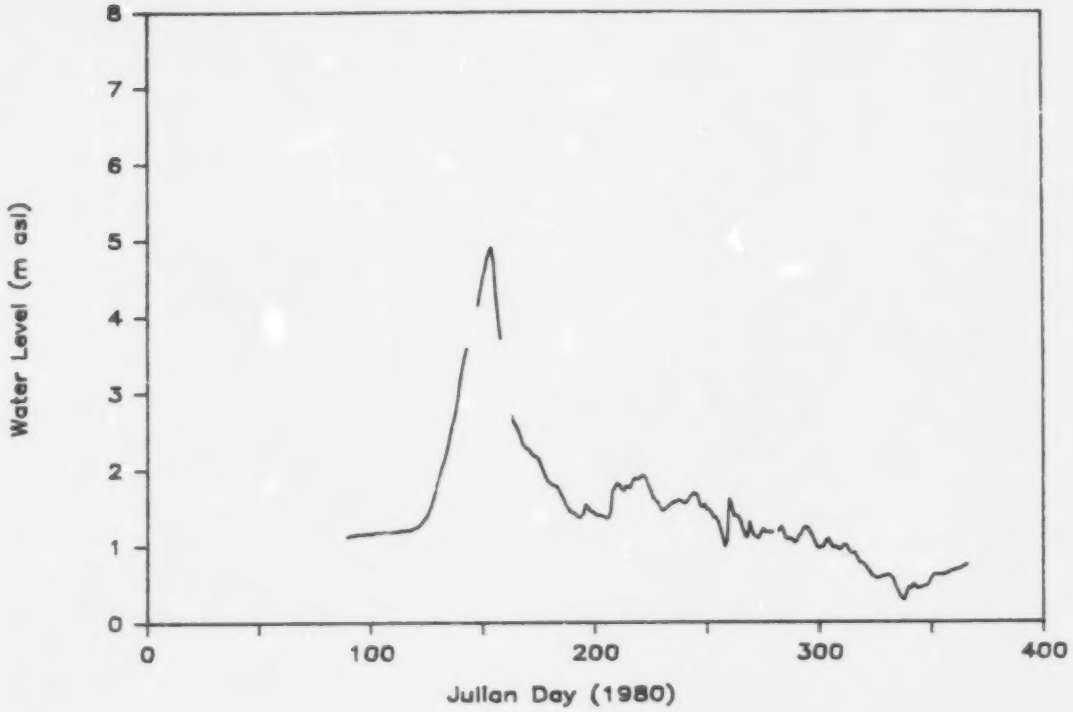
East Channel at Inuvik (WSC)



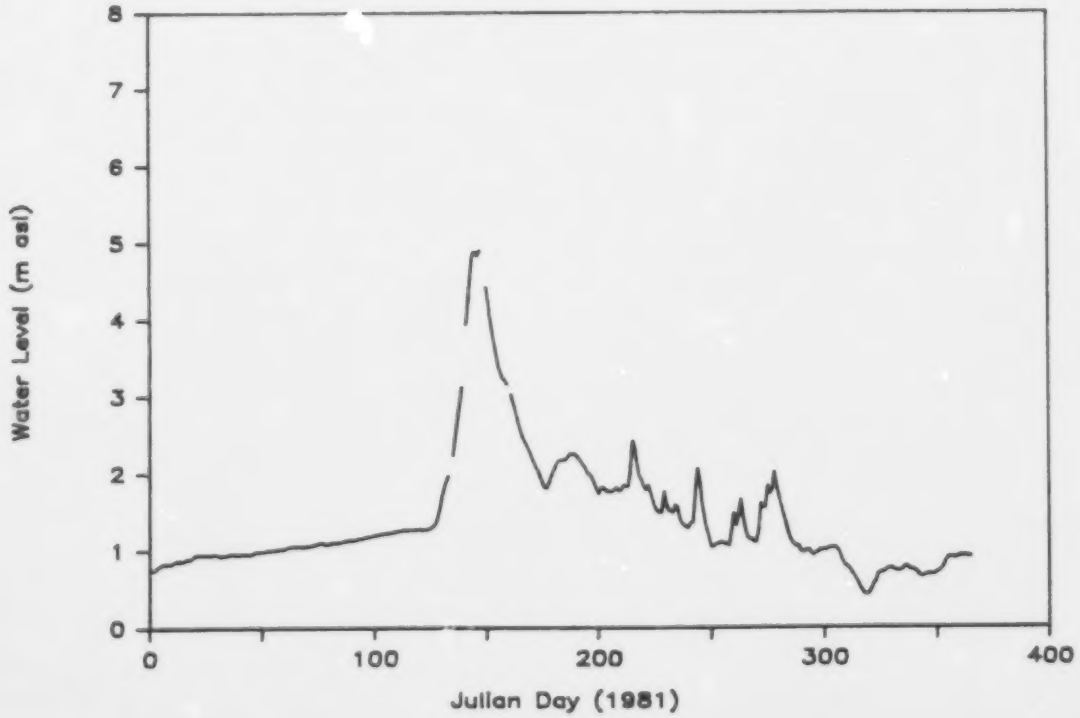
East Channel at Inuvik (WSC)



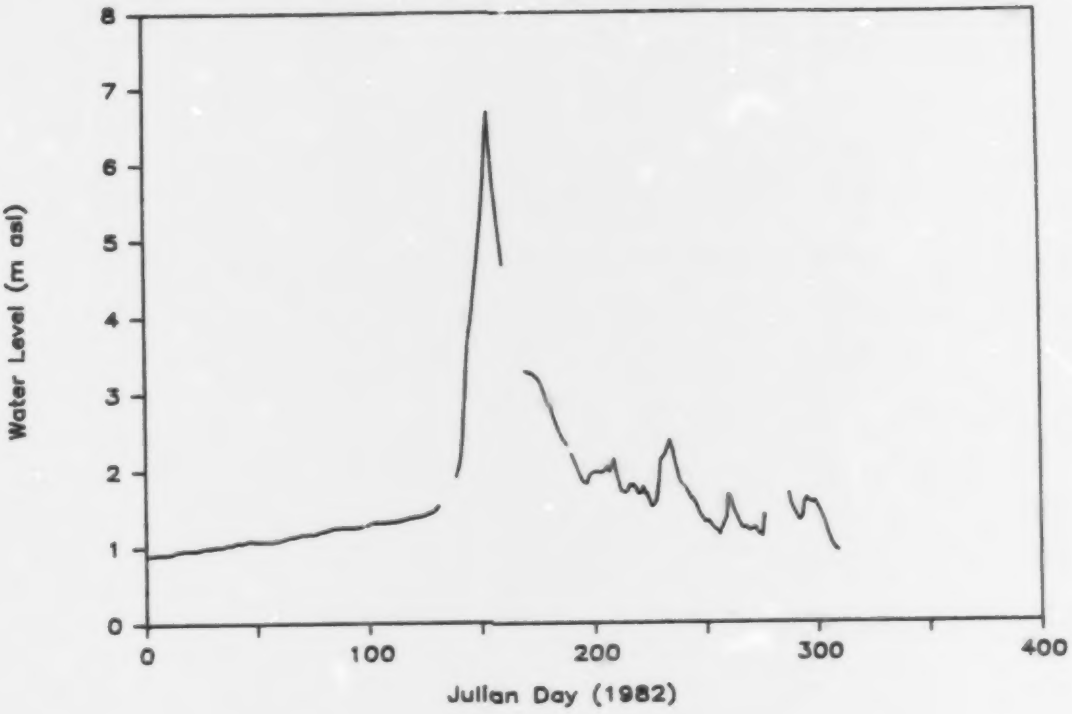
East Channel at Inuvik (WSC)



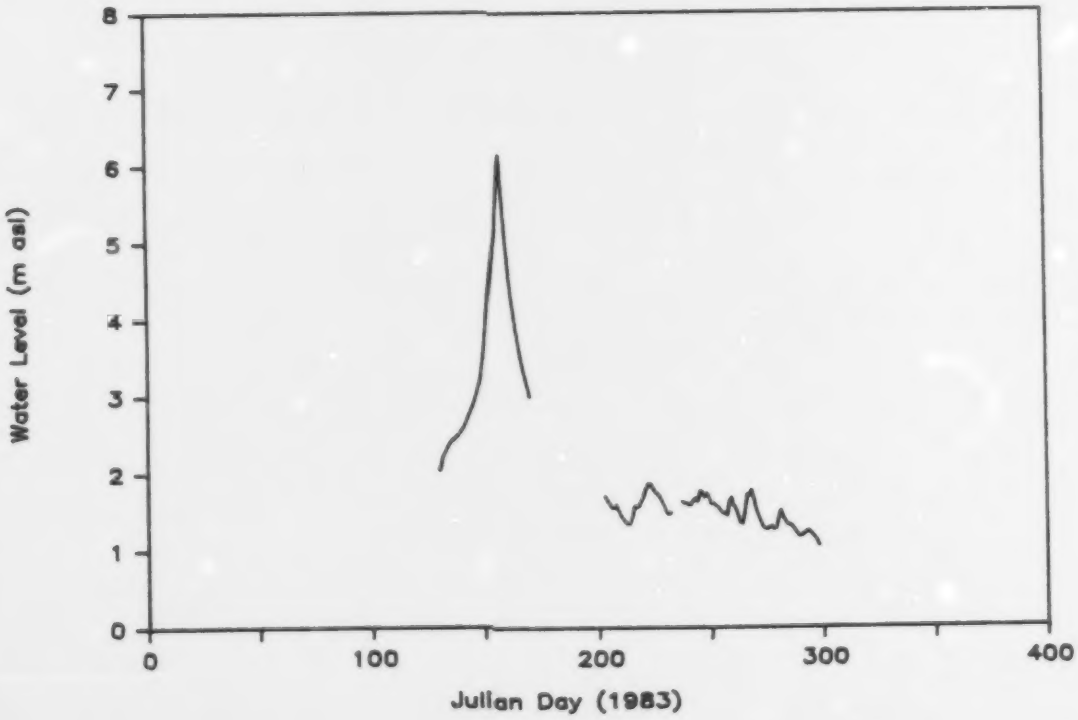
East Channel at Inuvik (WSC)



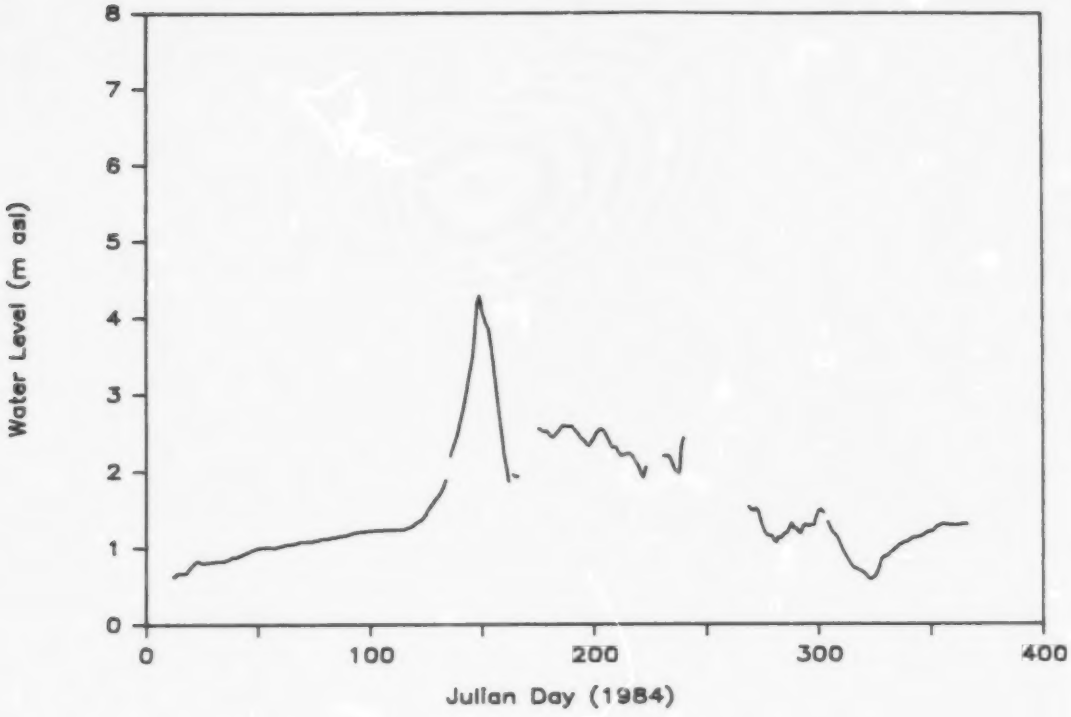
East Channel at Inuvik (WSC)



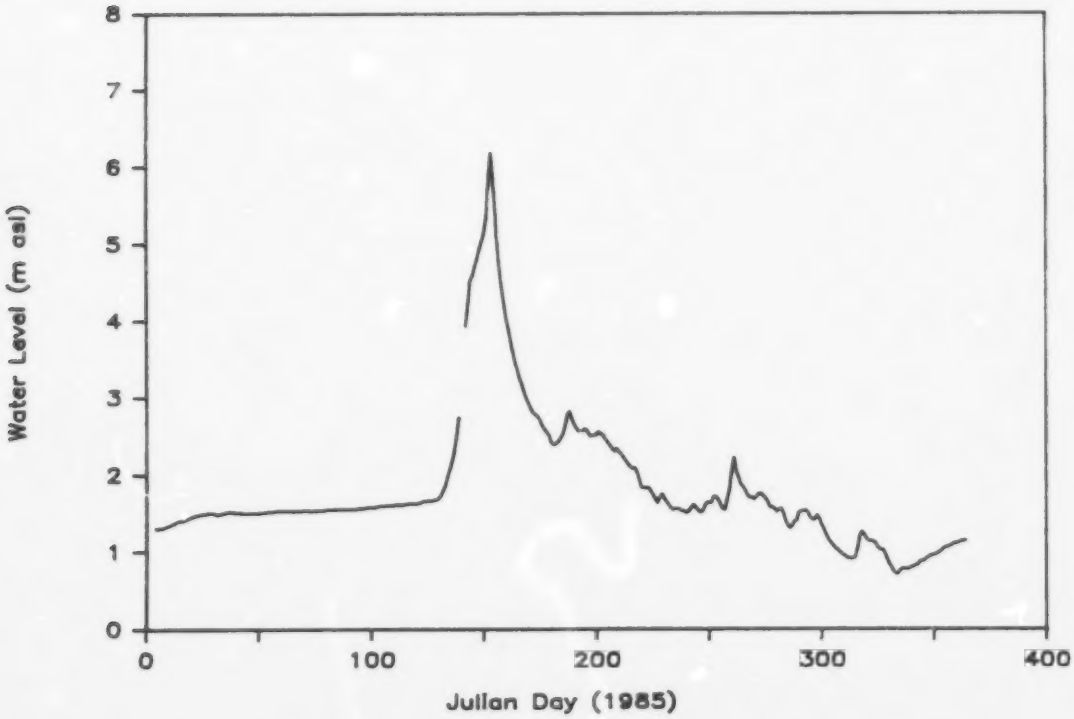
East Channel at Inuvik (WSC)



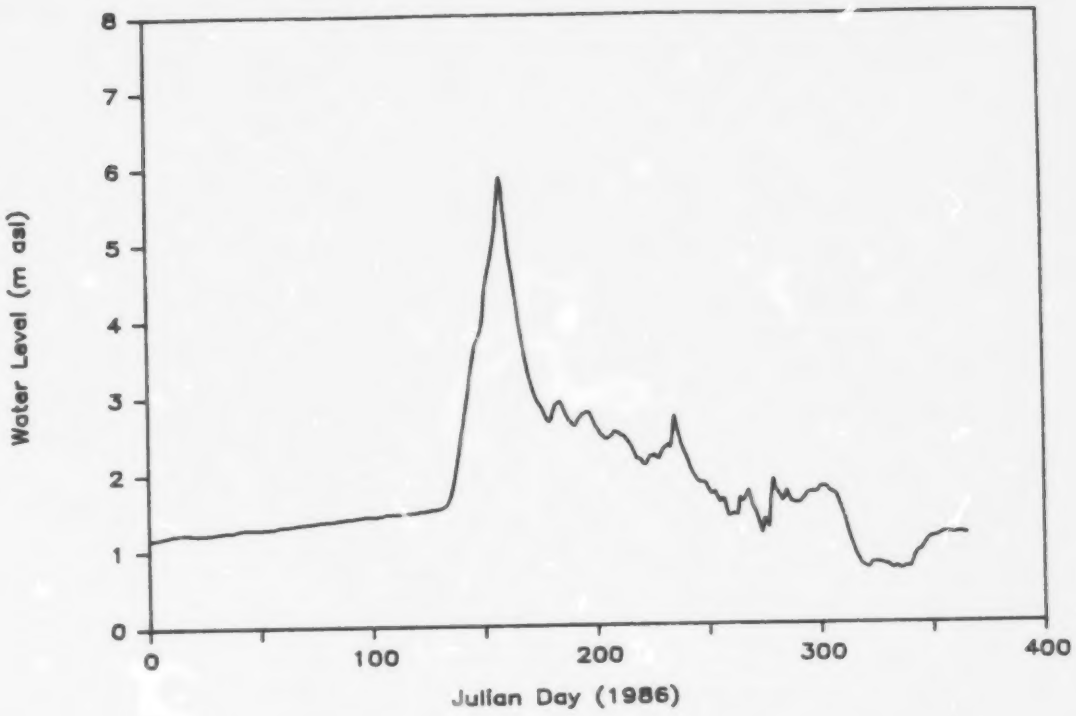
East Channel at Inuvik (WSC)



East Channel at Inuvik (WSC)



East Channel at Inuvik (WSC)



APPENDIX B: Summary Tables

B1. Julian dates of exceedance of given truncations for event 1.

Julian dates of exceedance of given truncations, for event 1

- Data from: (1) 1954 - Brown
(2) 1964-1973 - Inuvik Research Lab
(3) 1974-1986 - Water Survey of Canada

***** NOTE: (1) BLANK SPACES ARE MISSING DATA
(2) -- WATER LEVEL DID NOT REACH THIS LEVEL
(3) * WATER LEVEL WAS ABOVE THIS LEVEL ON MAY 1

Year	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
1954							151	153	154	156	159	--	--	--	--
1964		146	148	151	152	153	153	155	155	157	--	--	--	--	--
1965		133	138	145	147	149	152	160	--	--	--	--	--	--	--
1966		135	137	139	141	144	148	156	--	--	--	--	--	--	--
1967			134	138	141	144	148	151	154	156	157	--	--	--	--
1968		137	140	144	147	151	153	153	157	--	--	--	--	--	--
1969			131	134	137	141	145	151	--	--	--	--	--	--	--
1970		137	140	145	147	148	151	152	154	--	--	--	--	--	--
1971						139	141	143	145	149	151	--	--	--	--
1972			129	140	143	145	147	149	150	151	154	156	159	159	--
1973			130	134	136	138	139	143	145	147	149	--	--	--	--
1974		*	132	140	142	143	145	147	149	157	--	--	--	--	--
1975		123	132	134	135	137	140	143	147	149	--	--	--	--	--
1976		122	127	129	131	132	133	140	145	148	--	--	--	--	--
1977	*	121	131	135	138	140	142	148	150	--	--	--	--	--	--
1978	*	125	134	144	147	151	155	157	159	--	--	--	--	--	--
1979	*	128	137	140	141	143	145	146	147	148	--	--	--	--	--
1980		127	132	136	140	143	147	151	--	--	--	--	--	--	--
1981	*	129	134	137	139	140	142	143	--	--	--	--	--	--	--
1982	*	131	140	143	144	145	147	148	150	152	153	154	--	--	--
1983			130	139	147	150	152	153	155	156	157	--	--	--	--
1984	*	127	136	140	143	147	148	--	--	--	--	--	--	--	--
1985	*	*	135	138	140	141	143	144	149	152	153	--	--	--	--
1986	*	121	138	140	143	146	150	152	155	157	--	--	--	--	--
No.		15	22	22	22	23	24	23	18	14	8	2	1	1	0
Max.		146	148	151	152	153	153	160	157	157	159	156	159	159	
Mean		129.5	134.8	139.3	141.9	143.9	146.5	149.5	151.1	152.5	154.1	155.0	159.0	159.0	
St.dev.		7.1	4.8	4.8	4.9	5.1	5.3	5.3	4.4	3.9	3.4	1.0	0.0	0.0	
Min.		121	127	129	131	132	133	140	145	147	149	154	159	159	

B2. Duration of water levels greater than or equal to a given truncation level for event 1, subsequent events, and all events.

Duration of water levels greater than or equal to a given truncation level, for event 1 (days/season)

- Data from: (1) 1954 - Brown
  (2) 1964-1973 - Inuvik Research Lab
  (3) 1974-1986 - Water Survey of Canada

- Season = May 01 to September 30 (Julian days 121 to 273 inclusive), = 153 days.

***** NOTE: BLANK SPACES ARE MISSING DATA *****

Year	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
1954							13	10	8	5	1	0	0	0	0
1964							13	9	7	4	0	0	0	0	0
1965					20	15	10	1	0	0	0	0	0	0	0
1966					24	19	13	4	0	0	0	0	0	0	0
1967						24	17	10	8	3	1	0	0	0	0
1968					23	15	10	8	2	0	0	0	0	0	0
1969					26	18	13	5	0	0	0	0	0	0	0
1970					18	14	8	6	2	0	0	0	0	0	0
1971						20	16	13	9	4	1	0	0	0	0
1972								20	17	15	10	7	2	2	0
1973					34	26	21	13	10	6	3	0	0	0	0
1974	153	142	121	58	29	23	19	14	11	1	0	0	0	0	0
1975	153	134	85	63	37	30	23	17	11	7	0	0	0	0	0
1976	153	150	112	81	32	28	24	14	7	2	0	0	0	0	0
1977	153	112	70	55	32	20	15	6	2	0	0	0	0	0	0
1978	147	97	64	33	23	16	9	6	2	0	0	0	0	0	0
1979	153	126	93	67	25	18	13	10	8	3	0	0	0	0	0
1980	137	61	45	31	21	16	10	5	0	0	0	0	0	0	0
1981	153	98	40	29	23	14	10	5	0	0	0	0	0	0	0
1982	153	116	53	42	35	22	17	13	9	6	3	1	0	0	0
1983	153				24	17	12	9	5	3	1	0	0	0	0
1984	153		26	19	14	8	4	0	0	0	0	0	0	0	0
1985	153	153	84	42	29	22	18	14	8	3	1	0	0	0	0
1986	153	138	105	62	30	23	16	12	7	3	0	0	0	0	0
No.	13	11	12	12	19	21	23	24	24	24	24	24	24	24	24
Max.	153	153	121	81	37	30	24	20	17	15	10	7	2	2	0
Mean	151.3	120.6	74.8	48.5	26.3	19.4	14.1	9.3	5.5	2.7	0.9	0.3	0.1	0.1	0.0
S.dev.	4.4	26.3	28.9	17.8	6.0	5.1	4.8	4.8	4.6	3.4	2.1	1.4	0.4	0.4	0.0
Min.	137	61	26	19	14	8	4	0	0	0	0	0	0	0	0

Duration of water levels greater than or equal to a given truncation level, for events 2,3,4, etc. (days/season)

- Data from: (1) 1954 - Brown
  (2) 1964-1973 - Inuvik Research Lab
  (3) 1974-1986 - Water Survey of Canada

- Season = May 01 to September 30 (Julian days 121 to 273 inclusive), = 153 days.

***** NOTE: BLANK SPACES ARE MISSING DATA *****

Year	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
1954															
1964															
1965															
1966															
1967															
1968															
1969															
1970															
1971															
1972															
1973															
1974	0	2	0	31	14	0	0	0	0	0	0	0	0	0	0
1975	0	7	12	0	2	0	0	0	0	0	0	0	0	0	0
1976	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	10	12	0	11	0	0	0	0	0	0	0	0	0	0
1978	5	12	0	2	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0
1980	15	43	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	13	20	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	3	12	0	0	0	0	0	0	0	0	0	0	0	0
1983	0					0	0	0	0	0	0	0	0	0	0
1984	0	1			0	0	0	0	0	0	0	0	0	0	0
1985	0	0	3	19	0	0	0	0	0	0	0	0	0	0	0
1986	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0
No.	13	12	11	11	12	13	13	13	13	13	13	13	13	13	13
Max.	15	43	20	31	14	0	0	0	0	0	0	0	0	0	0
Mean	1.5	7.8	6.4	5.1	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S.dev.	4.1	11.6	6.9	9.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Duration of water levels greater than or equal to a given truncation level, for all events combined (days/season)

- Data from: (1) 1954 - Brown
  (2) 1964-1973 - Inuvik Research Lab
  (3) 1974-1986 - Water Survey of Canada

- Season = May 01 to September 30 (Julian days 121 to 273 inclusive), = 153 days.

***** NOTE: BLANK SPACES ARE MISSING DATA *****

Year	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
1954							13	10	8	5	1	0	0	0	0
1964							13	9	7	4	0	0	0	0	0
1965							10	1	0	0	0	0	0	0	0
1966							13	4	0	0	0	0	0	0	0
1967							17	10	8	3	1	0	0	0	0
1968							10	8	2	0	0	0	0	0	0
1969							13	5	0	0	0	0	0	0	0
1970							8	6	2	0	0	0	0	0	0
1971							16	13	9	4	1	0	0	0	0
1972								20	17	15	10	7	2	2	0
1973							21	13	10	6	3	0	0	0	0
1974	153	144	121	89	43	23	19	14	11	1	0	0	0	0	0
1975	153	141	97	63	39	30	23	17	11	7	0	0	0	0	0
1976	153	151	123	81	32	28	24	14	7	2	0	0	0	0	0
1977	153	122	82	55	43	20	15	6	2	0	0	0	0	0	0
1978	152	109	64	35	23	16	9	6	2	0	0	0	0	0	0
1979	153	126	93	67	32	18	13	10	8	3	0	0	0	0	0
1980	152	104	45	31	21	16	10	5	0	0	0	0	0	0	0
1981	153	111	60	29	23	14	10	5	0	0	0	0	0	0	0
1982	153	119	65	42	35	22	17	13	9	6	3	1	0	0	0
1983	153					17	12	9	5	3	1	0	0	0	0
1984	153				14	8	4	0	0	0	0	0	0	0	0
1985	153	153	87	61	29	22	18	14	8	3	1	0	0	0	0
1986	153	139	105	66	30	23	16	12	7	3	0	0	0	0	0
No.	13	11	11	11	12	13	23	24	24	24	24	24	24	24	24
Max.	153	153	123	89	43	30	24	20	17	15	10	7	2	2	0
Mean	152.8	129.0	85.6	56.3	30.3	19.8	14.1	9.3	5.5	2.7	0.9	0.3	0.1	0.1	0.0
S.dev.	0.4	16.6	24.2	19.1	8.6	5.6	4.8	4.8	4.6	3.4	2.1	1.4	0.4	0.4	0.0
Min.	152	104	45	29	14	8	4	0	0	0	0	0	0	0	0

B3. Extreme high and low water levels.

Extreme high and low water levels, Mackenzie River East Channel at Inuvik

- Data from: (1) 1954 - Brown
(2) 1964-1973 - Inuvik Research Lab
(3) 1974-1986 - Water Survey of Canada

***** NOTE: BLANK SPACES ARE MISSING DATA *****

	Max. spring levels		Max. summer levels		Min. summer levels	
Year	Julian day	Level (m asl)	Julian day	Level (m asl)	Julian day	Level (m asl)
1954	160	6.35				
1964	159	5.84				
1965	160	4.60				
1966	156	4.82				
1967	157	6.12				
1968	158	5.21				
1969	153	4.60				
1970	154	5.13				
1971	151	6.17				
1972	159	7.820				
1973	149	6.450				
1974	157	5.570	233	3.430	272	1.312
1975	152	5.832	190	3.034	273	1.309
1976	149	5.557	192	2.830	272	1.486
1977	151	5.269	174	3.260	267	1.182
1978	160	5.250	179	2.504	268	0.995
1979	148	5.717	194	3.181	273	1.214
1980	154	4.914	221	1.929	258	0.990
1981	147	4.904	215	2.425	250	1.038
1982	154	6.686	234	2.381	256	1.152
1983	157	6.156			273	1.301
1984	149	4.298	186	2.597		
1985	153	6.194	188	2.826	240	1.505
1986	158	5.868	184	2.926	273	1.283
1987	154	5.570				
mean	154.36	5.636	199.17	2.777	264.58	1.231
s. dev.	4.09	0.766	20.03	0.411	10.59	0.163
# obs.	25	25	12	12	12	12

B4. Number of occurrences of event 1, subsequent events, and all events.

Number of occurrences of event 1

- Data from: (1) 1954 - Brown
(2) 1964-1973 - Inuvik Research Lab
(3) 1974-1986 - Water Survey of Canada

***** NOTE: BLANK SPACES ARE MISSING DATA *****

Year	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
1954							1	1	1	1	1	0	0	0	0
1964							1	1	1	1	0	0	0	0	0
1965					1	1	1	1	0	0	0	0	0	0	0
1966					1	1	1	1	0	0	0	0	0	0	0
1967						1	1	1	1	1	1	0	0	0	0
1968					1	1	1	1	1	0	0	0	0	0	0
1969					1	1	1	1	0	0	0	0	0	0	0
1970					1	1	1	1	1	0	0	0	0	0	0
1971						1	1	1	1	1	1	0	0	0	0
1972								1	1	1	1	1	1	1	0
1973					1	1	1	1	1	1	1	0	0	0	0
1974	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
1975	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
1976	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
1977	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
1978	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
1979	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
1980	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
1981	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
1982	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
1983	1				1	1	1	1	1	1	1	0	0	0	0
1984	1		1	1	1	1	1	0	0	0	0	0	0	0	0
1985	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
1986	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
No.	13	11	12	12	19	21	23	24	24	24	24	24	24	24	24
Max.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Mean	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.75	0.58	0.33	0.08	0.04	0.04	0.00
S.dev.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.43	0.49	0.47	0.28	0.20	0.20	0.00
Min.	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Number of occurrences of event 2,3,4, etc.

- Data from: (1) 1954 - Brown
  (2) 1964-1973 - Inuvik Research Lab
  (3) 1974-1986 - Water Survey of Canada

***** NOTE: BLANK SPACES ARE MISSING DATA *****

Year	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
1954															
1964															
1965															
1966															
1967															
1968															
1969															
1970															
1971															
1972															
1973															
1974	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0
1975	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0
1976	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0
1978	1	3	0	1	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1980	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	5	3	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0
1983	0					0	0	0	0	0	0	0	0	0	0
1984	0	1			0	0	0	0	0	0	0	0	0	0	0
1985	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
1986	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0
No.	13	12	11	11	12	13	13	13	13	13	13	13	13	13	13
Max.	1	5	3	2	1	0	0	0	0	0	0	0	0	0	0
Mean	0.15	1.75	1.09	0.55	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S.dev.	0.36	1.48	1.16	0.78	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Number of occurrences of all events combined

- Data from: (1) 1954 - Brown
(2) 1964-1973 - Inuvik Research Lab
(3) 1974-1986 - Water Survey of Canada

***** NOTE: BLANK SPACES ARE MISSING DATA *****

Year	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
1954							1	1	1	1	1	0	0	0	0
1964							1	1	1	1	0	0	0	0	0
1965							1	1	0	0	0	0	0	0	0
1966							1	1	0	0	0	0	0	0	0
1967							1	1	1	1	1	0	0	0	0
1968							1	1	1	0	0	0	0	0	0
1969							1	1	0	0	0	0	0	0	0
1970							1	1	1	0	0	0	0	0	0
1971							1	1	1	1	1	0	0	0	0
1972								1	1	1	1	1	1	1	0
1973							1	1	1	1	1	0	0	0	0
1974	1	2	1	3	2	1	1	1	1	1	0	0	0	0	0
1975	1	3	3	1	2	1	1	1	1	1	0	0	0	0	0
1976	1	2	2	1	1	1	1	1	1	1	0	0	0	0	0
1977	1	3	3	1	2	1	1	1	1	0	0	0	0	0	0
1978	2	4	1	2	1	1	1	1	1	0	0	0	0	0	0
1979	1	1	1	1	2	1	1	1	1	1	0	0	0	0	0
1980	2	5	1	1	1	1	1	1	0	0	0	0	0	0	0
1981	1	6	4	1	1	1	1	1	0	0	0	0	0	0	0
1982	1	2	4	1	1	1	1	1	1	1	1	1	0	0	0
1983	1					1	1	1	1	1	1	0	0	0	0
1984	1				1	1	1	0	0	0	0	0	0	0	0
1985	1	1	2	2	1	1	1	1	1	1	1	0	0	0	0
1986	1	2	1	3	1	1	1	1	1	1	0	0	0	0	0
No.	13	11	11	11	12	13	23	24	24	24	24	24	24	24	24
Max.	2	6	4	3	2	1	1	1	1	1	1	1	1	1	0
Mean	1.15	2.82	2.09	1.55	1.33	1.00	1.00	0.96	0.75	0.58	0.33	0.08	0.04	0.04	0.00
S.dev.	0.36	1.53	1.16	0.78	0.47	0.00	0.00	0.20	0.43	0.49	0.47	0.28	0.20	0.20	0.00
Min.	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

B5. Number of inflow events above given sill levels.

Number of inflow events above given sill levels

- Data from: (1) 1954 - Brown
(2) 1964-1973 - Inuvik Research Lab
(3) 1974-1986 - Water Survey of Canada

***** NOTE: BLANK SPACES ARE MISSING DATA *****

Year	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
1954									1	1	1	0	0	0	0
1964								1	1	1	0	0	0	0	0
1965						2	2	1	0	0	0	0	0	0	0
1966					3	3	3	2	0	0	0	0	0	0	0
1967						3	2	2	1	1	1	0	0	0	0
1968						1	1	1	1	0	0	0	0	0	0
1969					2	2	2	1	0	0	0	0	0	0	0
1970						1	1	1	1	0	0	0	0	0	0
1971					1	1	1	1	1	1	1	0	0	0	0
1972								1	1	1	1	1	1	1	0
1973						1	1	1	1	1	1	1	0	0	0
1974	12	12	10	8	4	2	2	2	2	1	0	0	0	0	0
1975	15	14	8	3	3	2	2	2	2	1	0	0	0	0	0
1976	16	16	13	6	1	1	1	1	1	1	0	0	0	0	0
1977	15	10	6	4	4	1	1	1	1	0	0	0	0	0	0
1978	12	11	4	2	1	1	1	1	1	0	0	0	0	0	0
1979	11	7	4	3	2	1	1	1	1	1	0	0	0	0	0
1980	16	10	1	1	1	1	1	1	0	0	0	0	0	0	0
1981	18	14	6	2	2	2	2	2	0	0	0	0	0	0	0
1982	11	8	4	1	1	1	1	1	1	1	1	1	0	0	0
1983							1	1	1	1	1	0	0	0	0
1984						1	1	0	0	0	0	0	0	0	0
1985	15	15	7	4	1	1	1	1	1	1	1	0	0	0	0
1986	16	15	8	5	1	1	1	1	1	1	0	0	0	0	0
No.	11	11	11	11	14	20	21	23	24	24	24	24	24	24	24
Max.	18	16	13	8	4	3	3	2	2	1	1	1	1	1	0
Mean	14.3	12.0	6.5	3.5	1.9	1.5	1.4	1.2	0.8	0.6	0.3	0.1	0.0	0.0	0.0
S.dev.	2.3	2.9	3.1	2.1	1.1	0.7	0.6	0.5	0.6	0.5	0.5	0.3	0.2	0.2	0.0
Min.	11	7	1	1	1	1	1	0	0	0	0	0	0	0	0

APPENDIX C: Partial Duration Series

C1. Summary table.

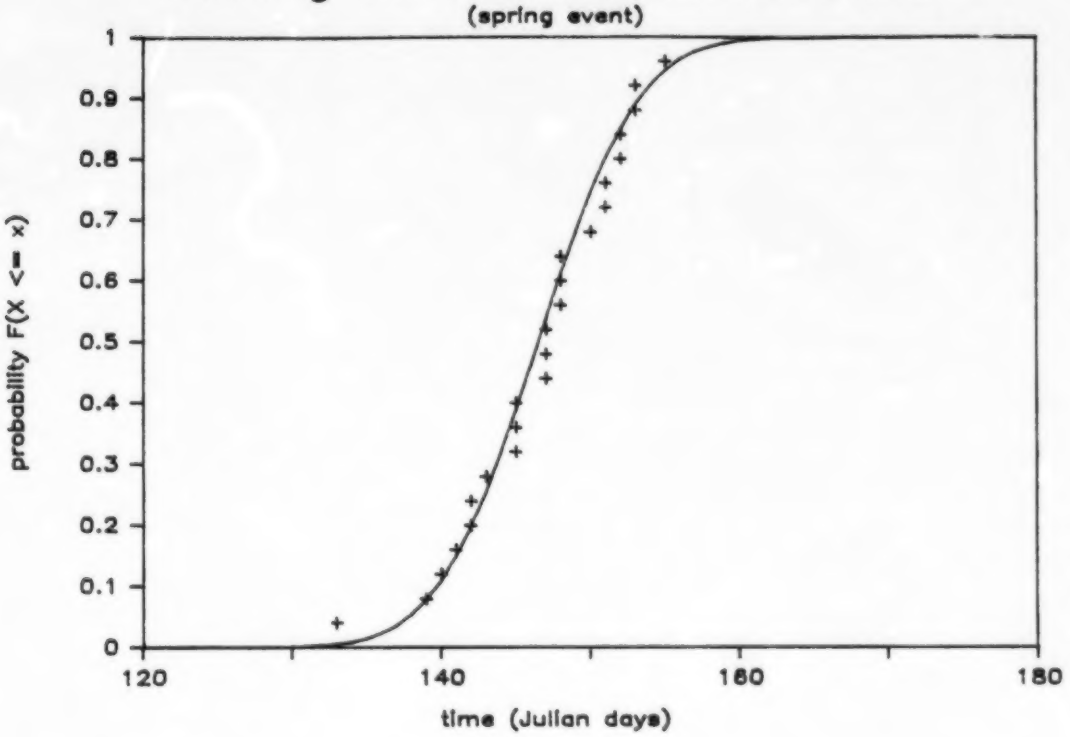
Parameters for partial duration series

Sill level (m asl)	Mean mag. above level (m asl)	Mean dura. of event 1 (days/event)	Timing of exceedance of levels mean date	st. dev.
4	1.643	14.09	day 146.54	5.31 days
4.5	1.202	9.74	day 149.48	5.26 days
5	0.961	7.39	day 151.11	4.37 days
5.5	0.674	4.64	day 152.50	3.88 days
6	0.507	2.63	day 154.13	3.36 days

C2. Julian dates of exceedance of given truncations - normal distribution.

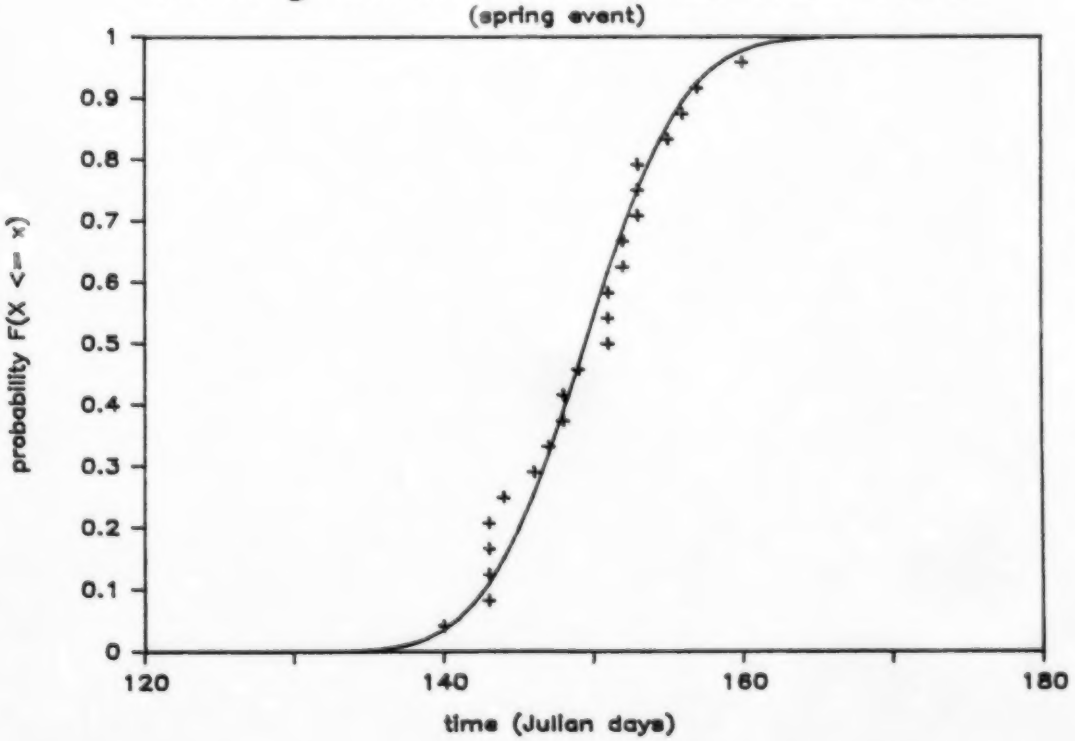
Timing of the 4m exceedance

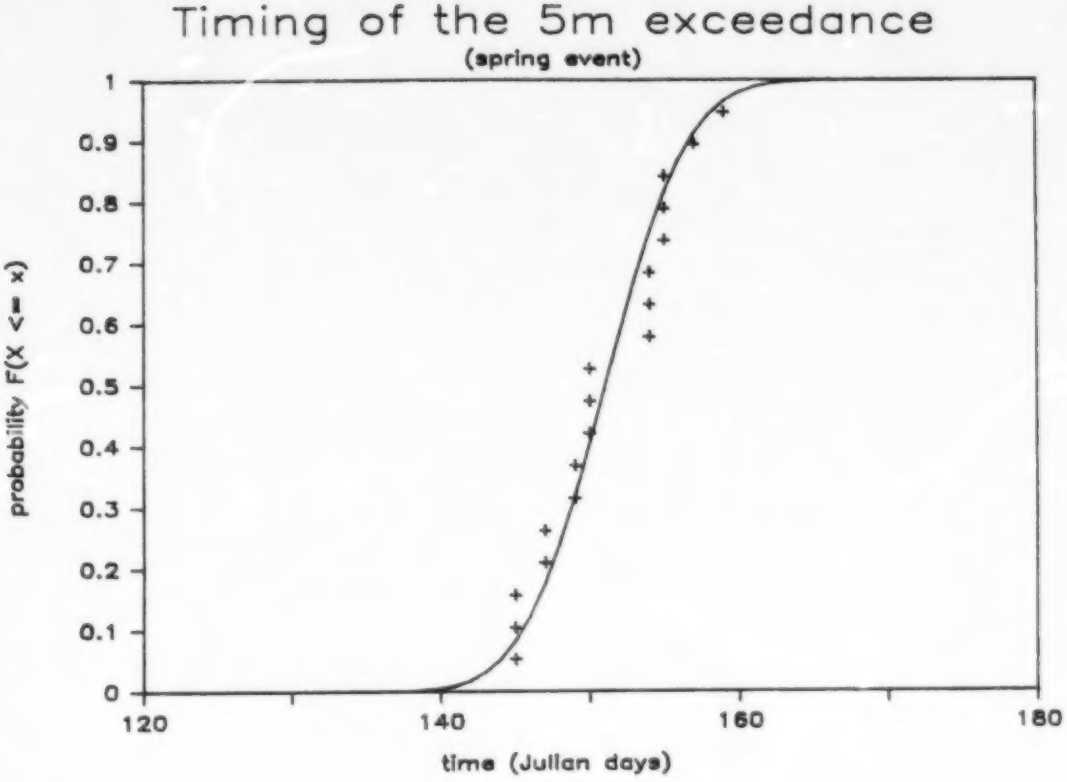
(spring event)

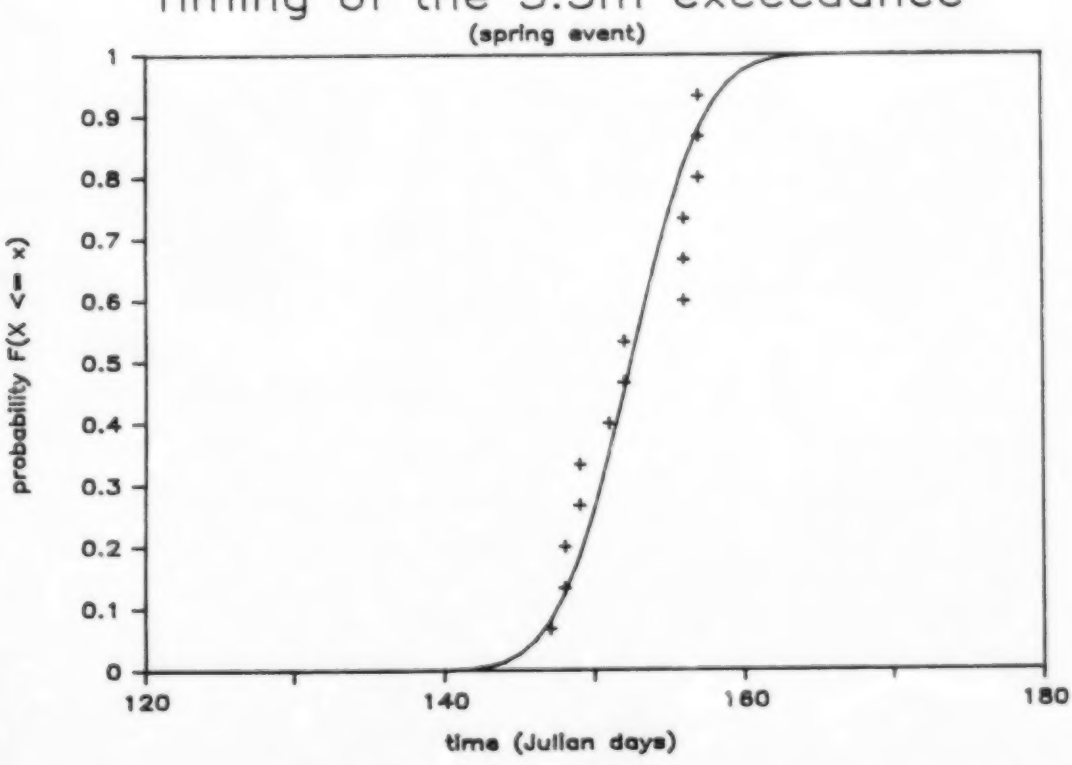


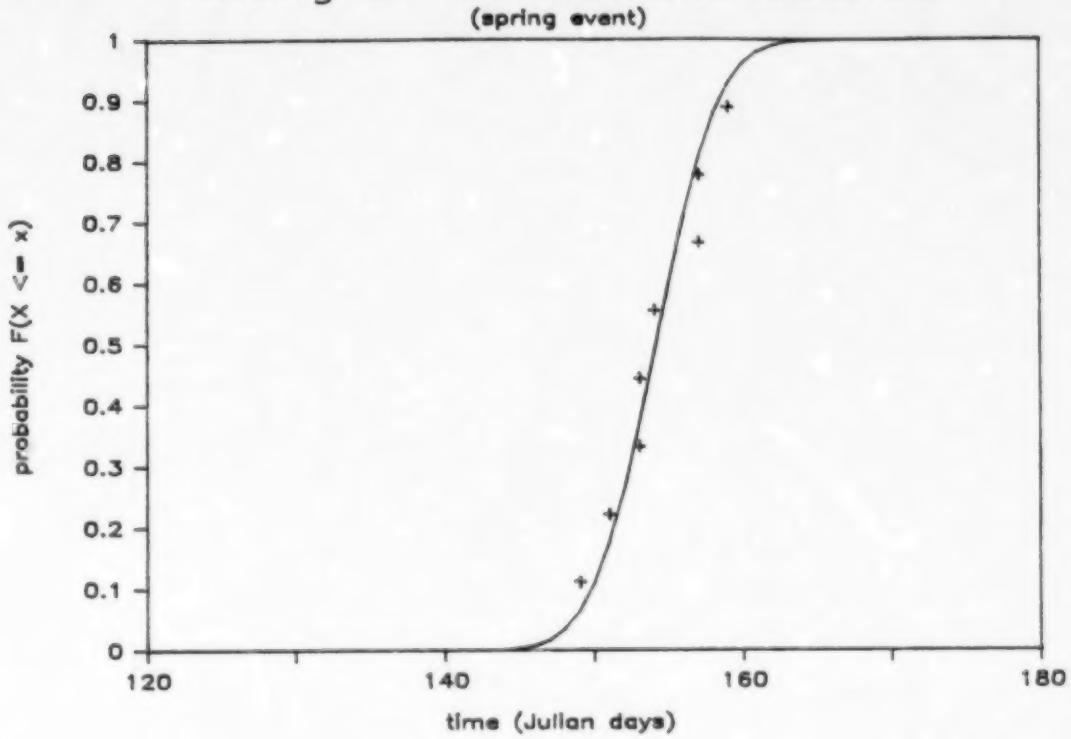
Timing of the 4.5m exceedance

(spring event)

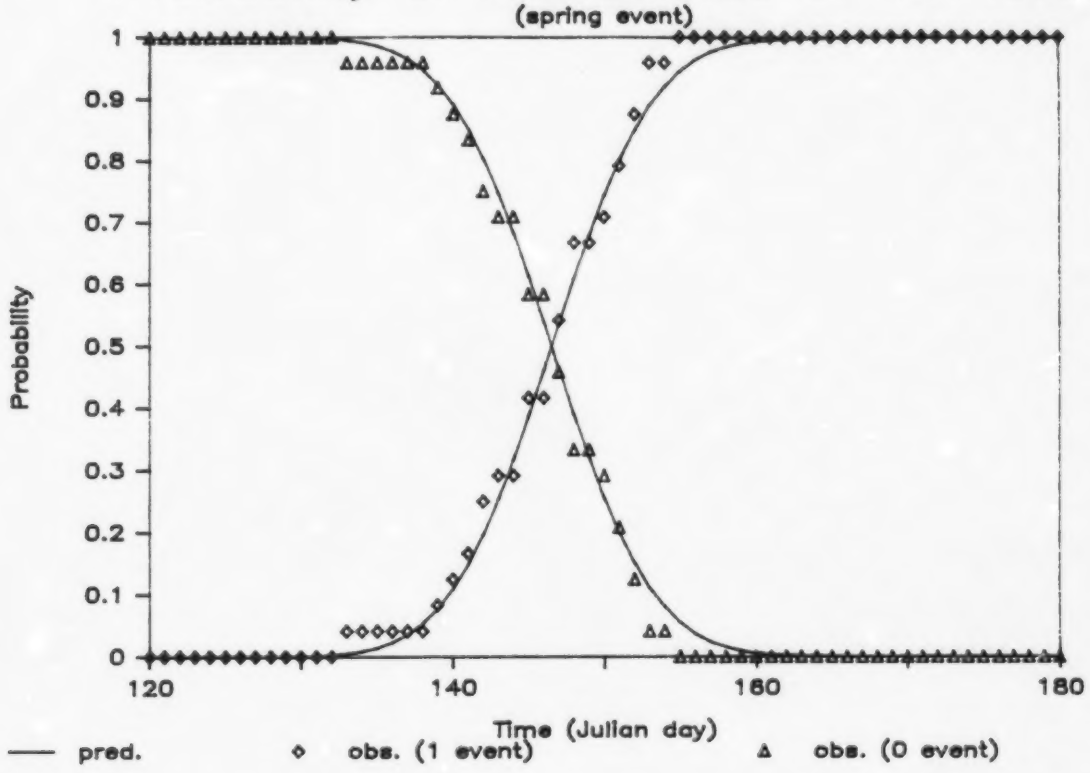


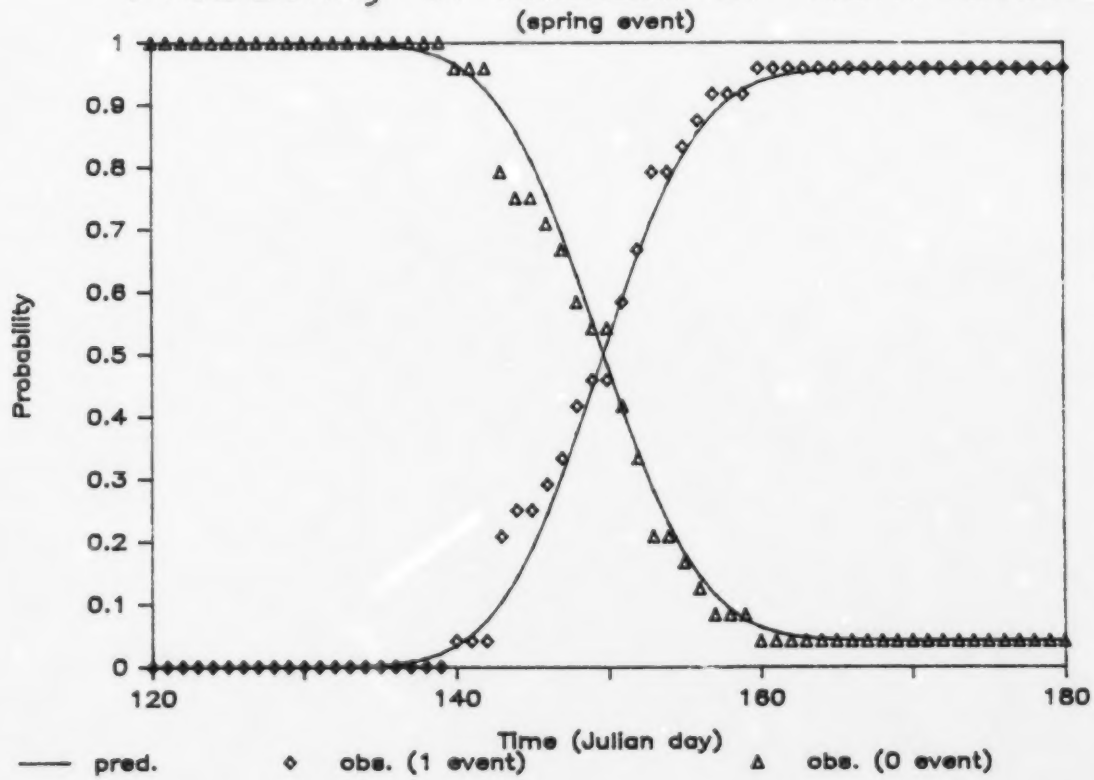

Timing of the 5m exceedance
(spring event)
probability F(X <= x)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
120
140
160
180
time (Julian days)

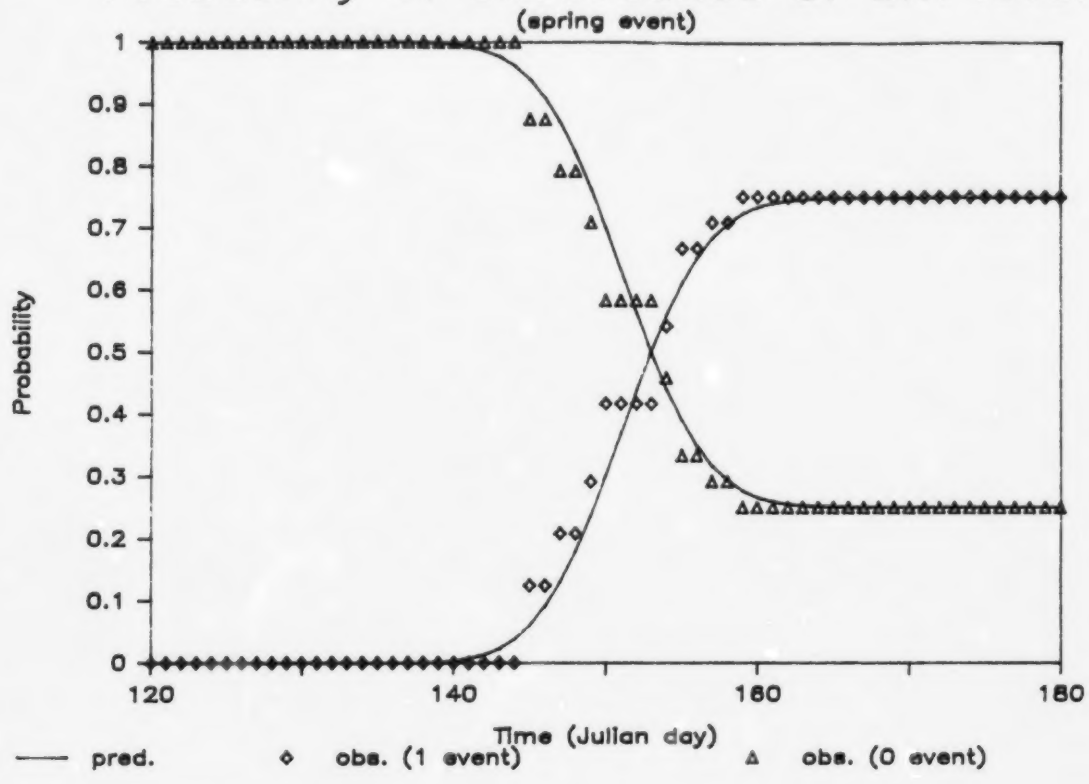

Timing of the 5.5m exceedance
(spring event)
probability F(X <= x)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
120
140
160
180
time (Julian days)

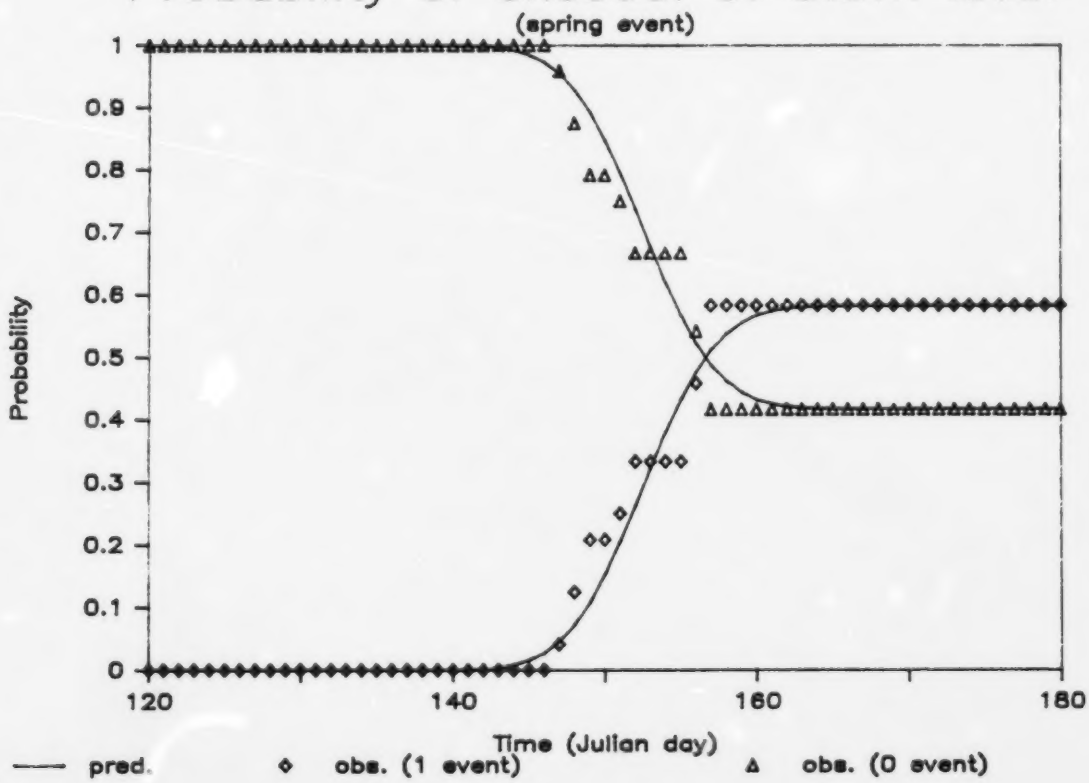

Timing of the 6m exceedance
(spring event)
probability F(X <= x)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
120
140
160
180
time (Julian days)

C3. Probability of having zero or one event by a given date.

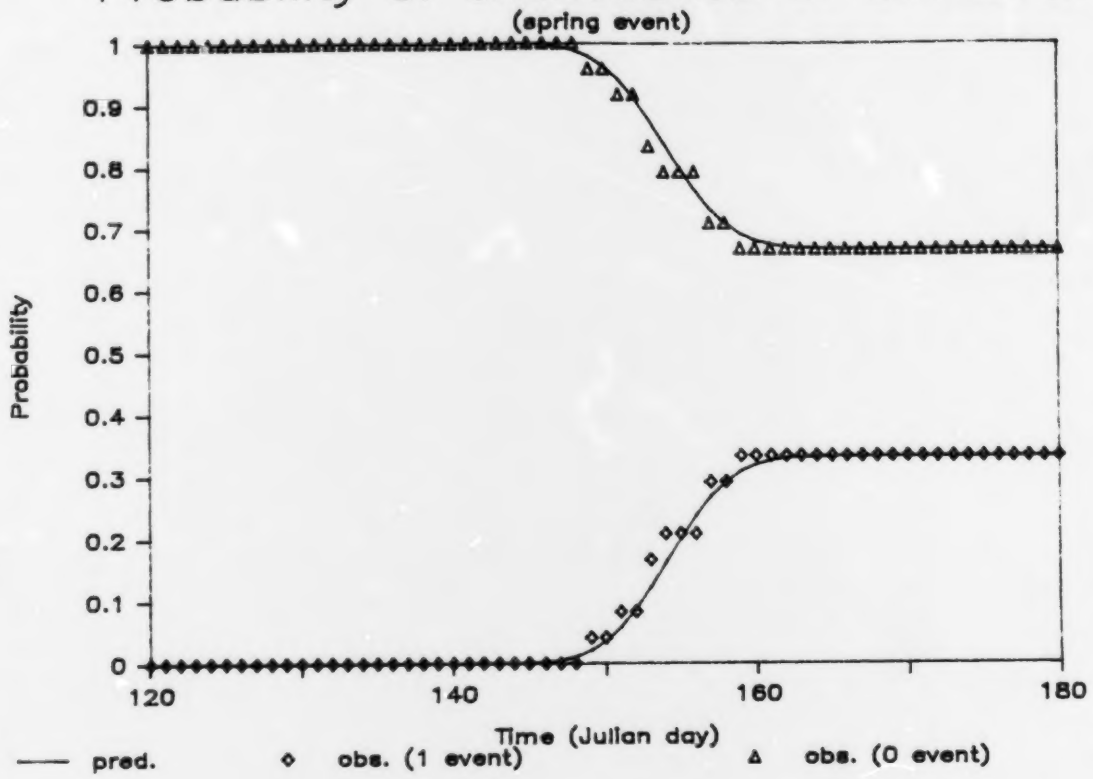

Probability of exceedance of 4m level
(spring event)
Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
120
140
160
180
Time (Julian day)
pred.
obs. (1 event)
obs. (0 event)


Probability of exceed. of 4.5m level
(spring event)
Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
120
140
160
180
Time (Julian day)
pred.
obs. (1 event)
obs. (0 event)


Probability of exceedance of 5m level
(spring event)
Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
120
140
160
180
Time (Julian day)
pred.
obs. (1 event)
obs. (0 event)

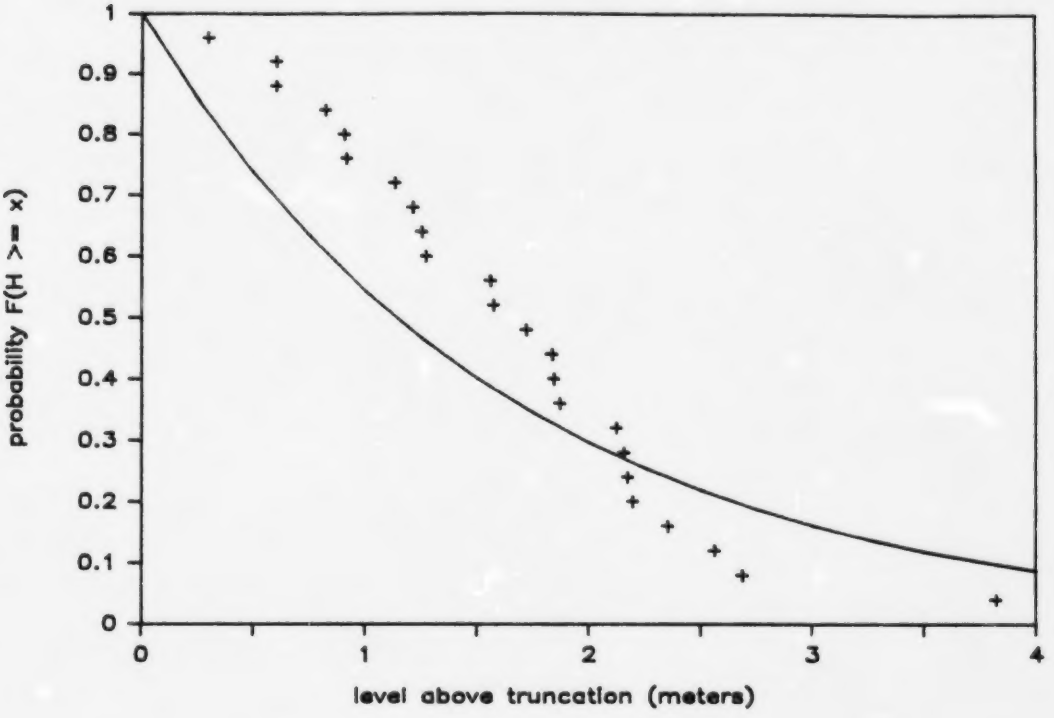

Probability of exceed. of 5.5m level
(spring event)
Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
120
140
160
180
Time (Julian day)
pred.
obs. (1 event)
obs. (0 event)

Probability of exceedance of 6m level

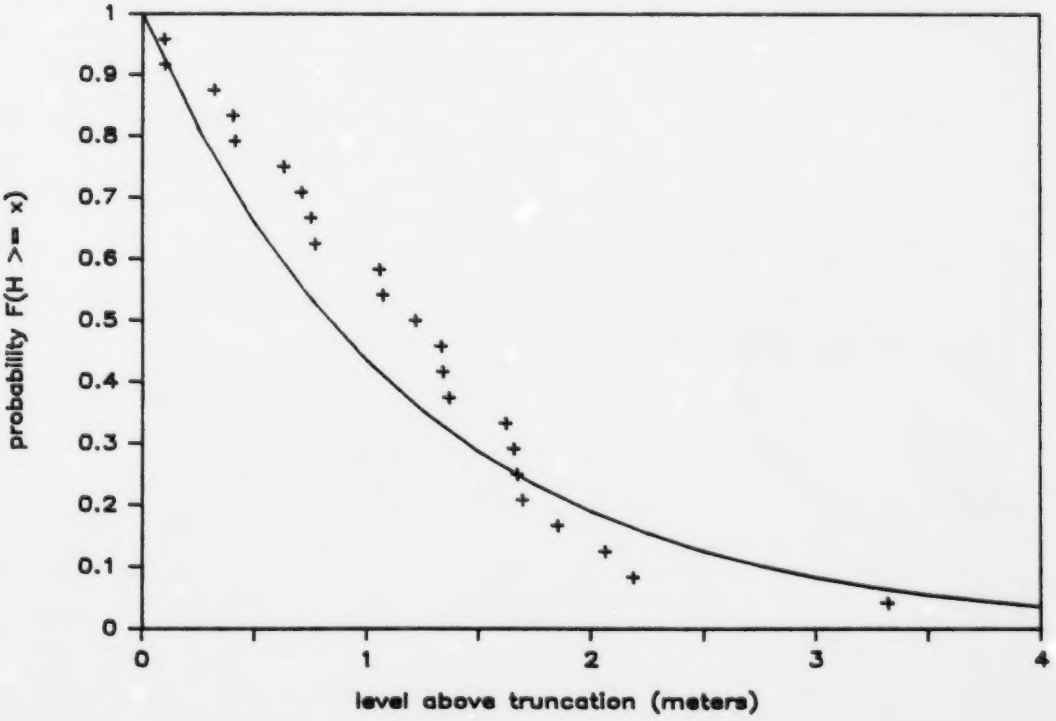


C4. Magnitude of peak levels above given truncations.

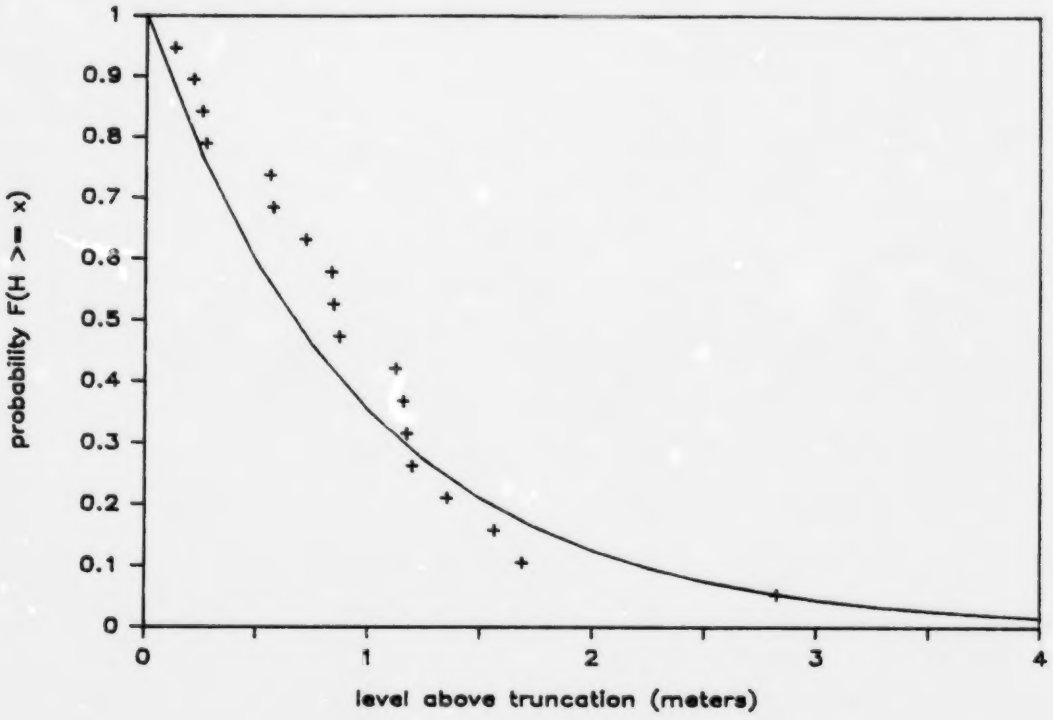
Level of flow >= 4 meters



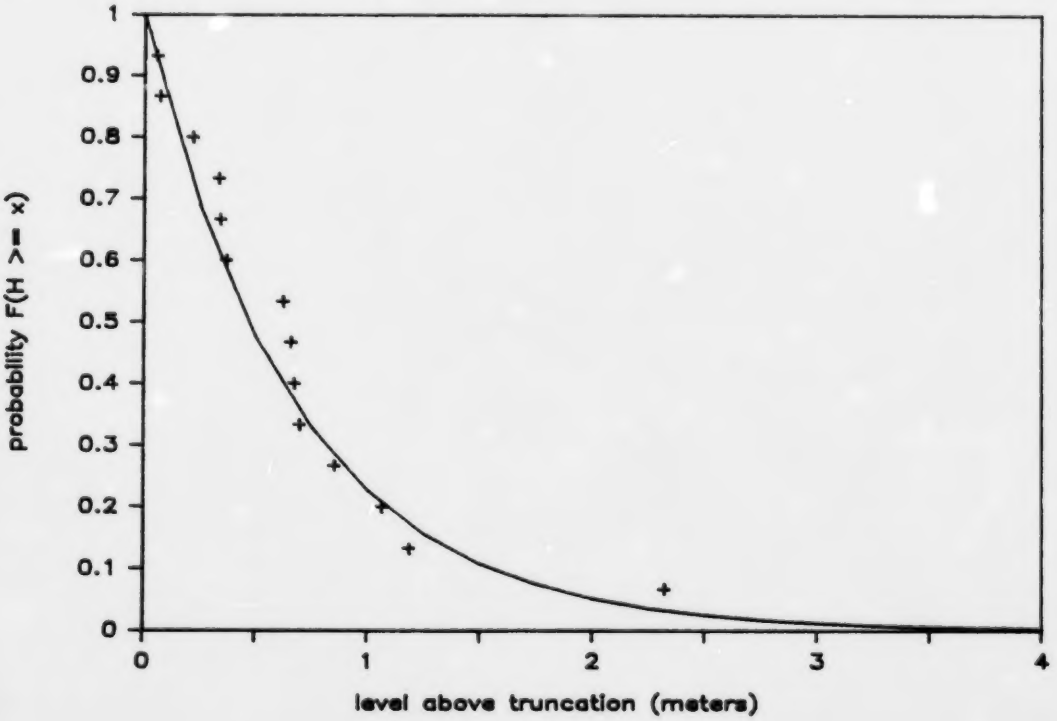
Level of flow >= 4.5 meters



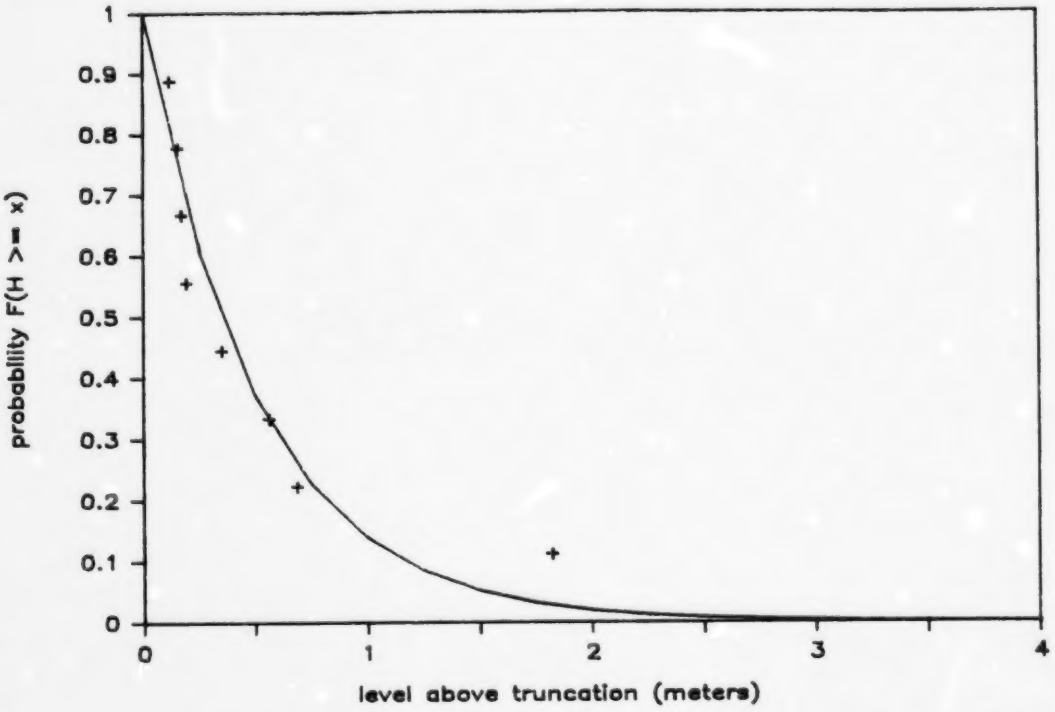
Level of flow >= 5 meters



Level of flow >= 5.5 meters



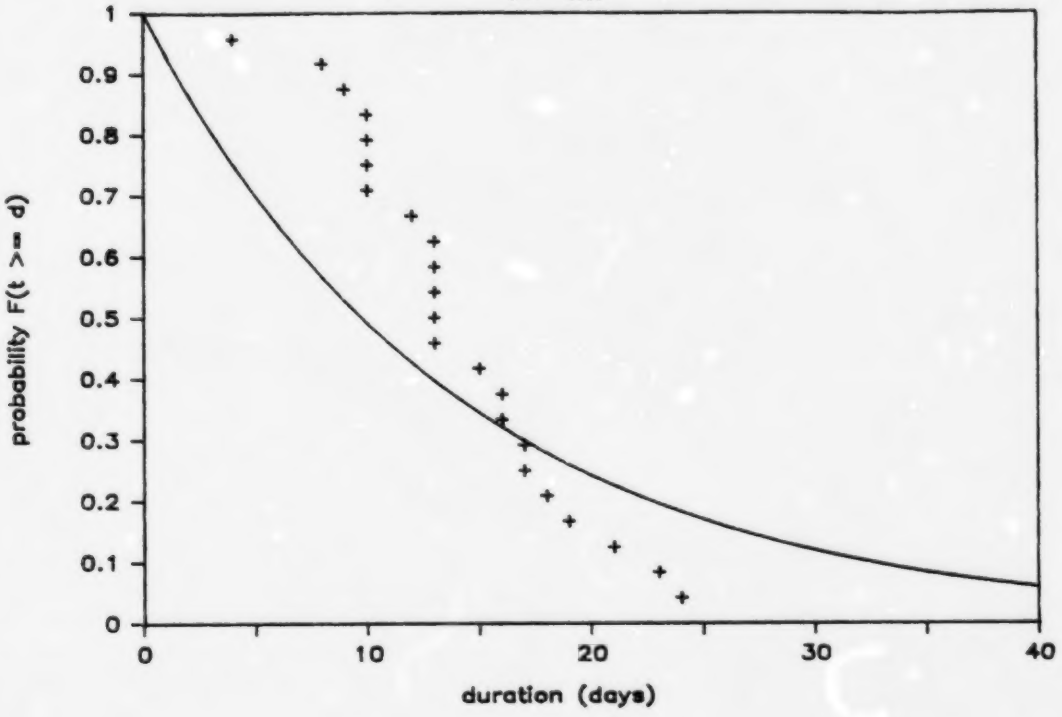
Level of flow >= 6 meters



C5. Duration of event above given truncation levels.

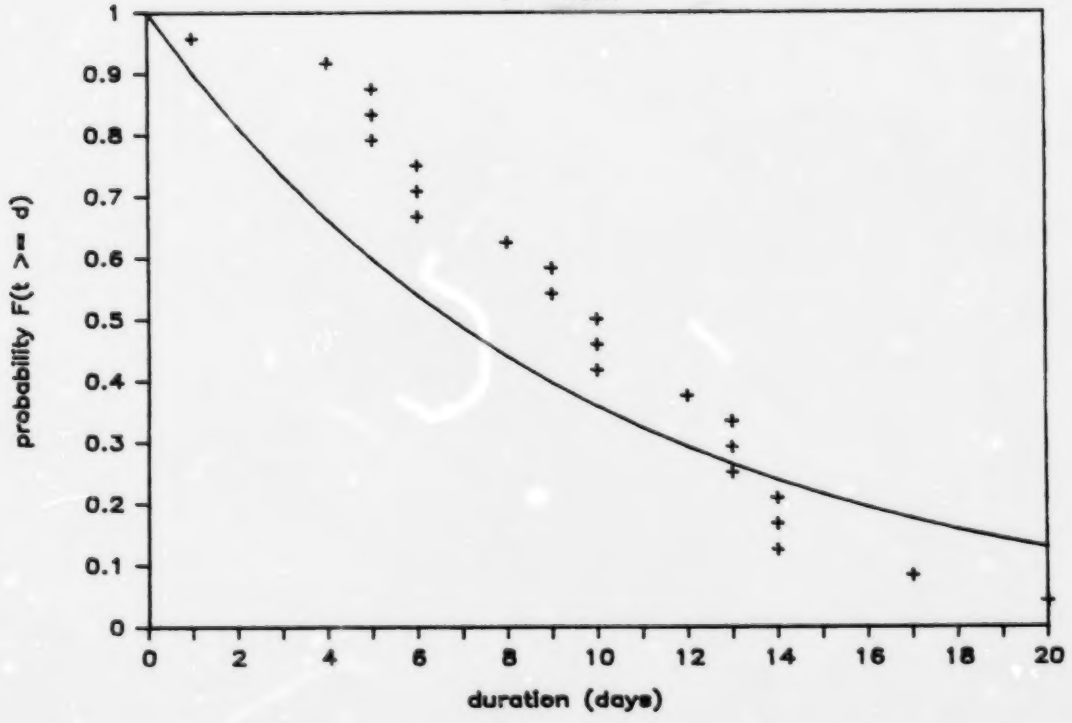
Observed vs Predicted Durations

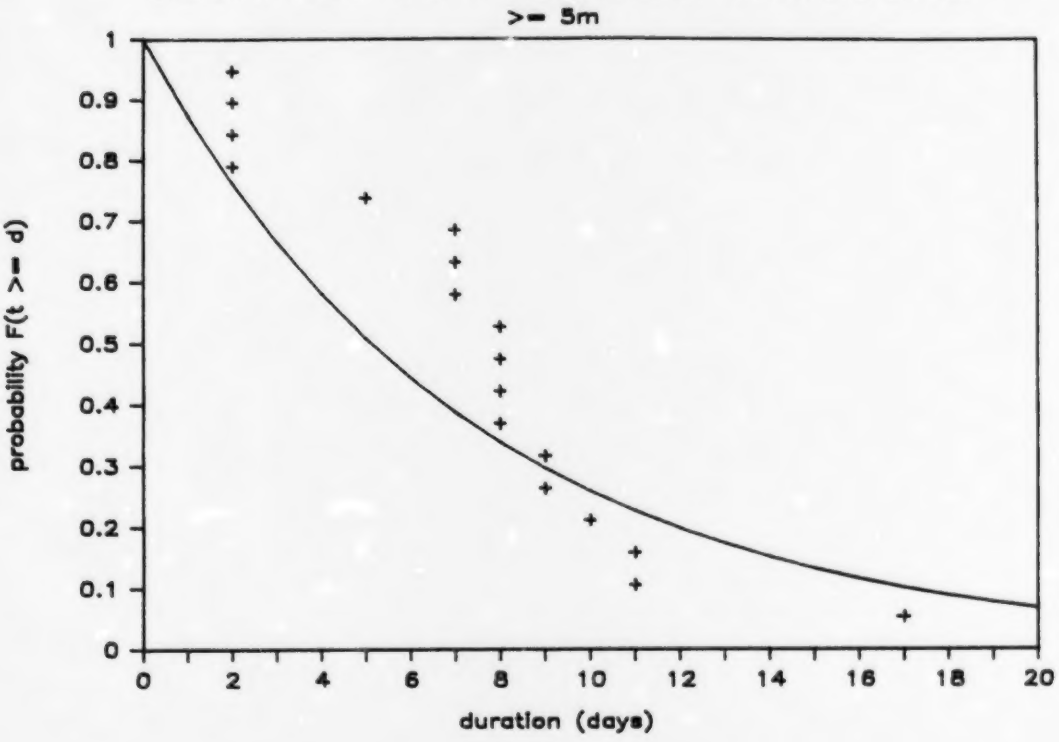
>= 4m

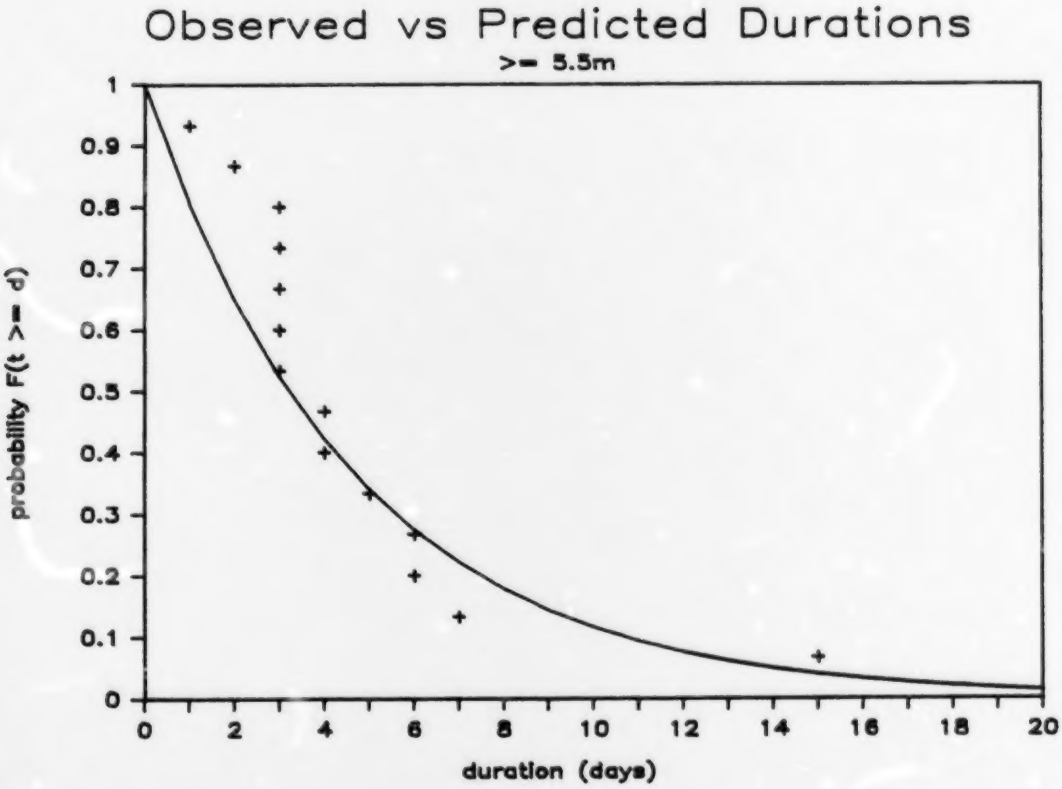


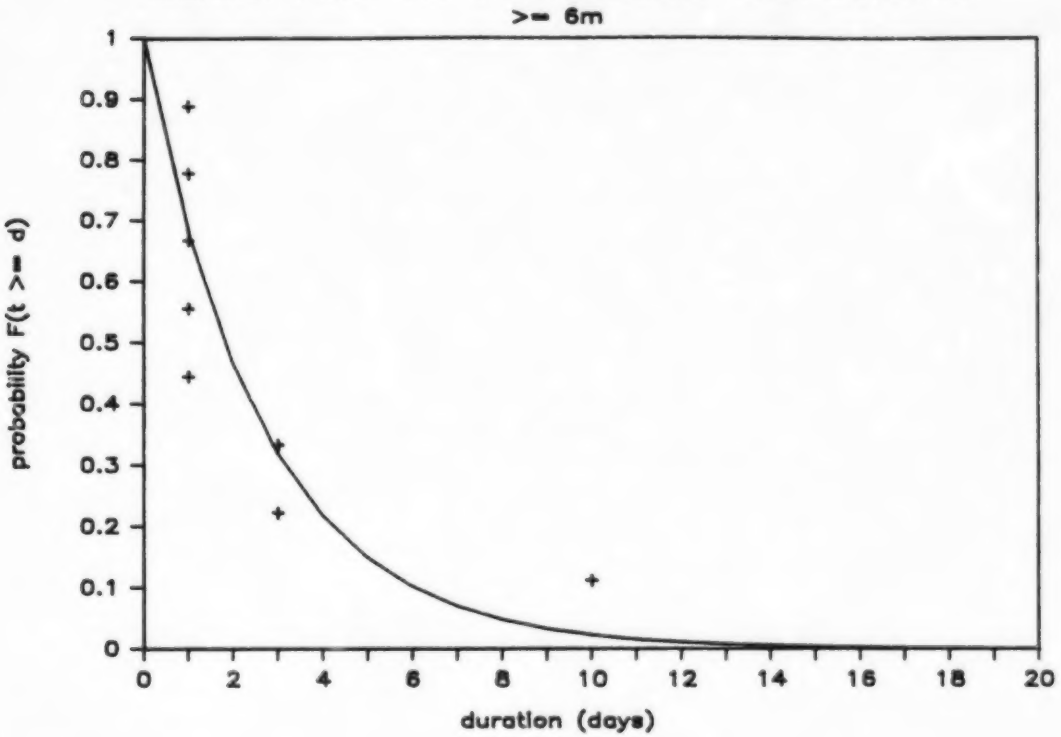
Observed vs Predicted Durations

>= 4.5m



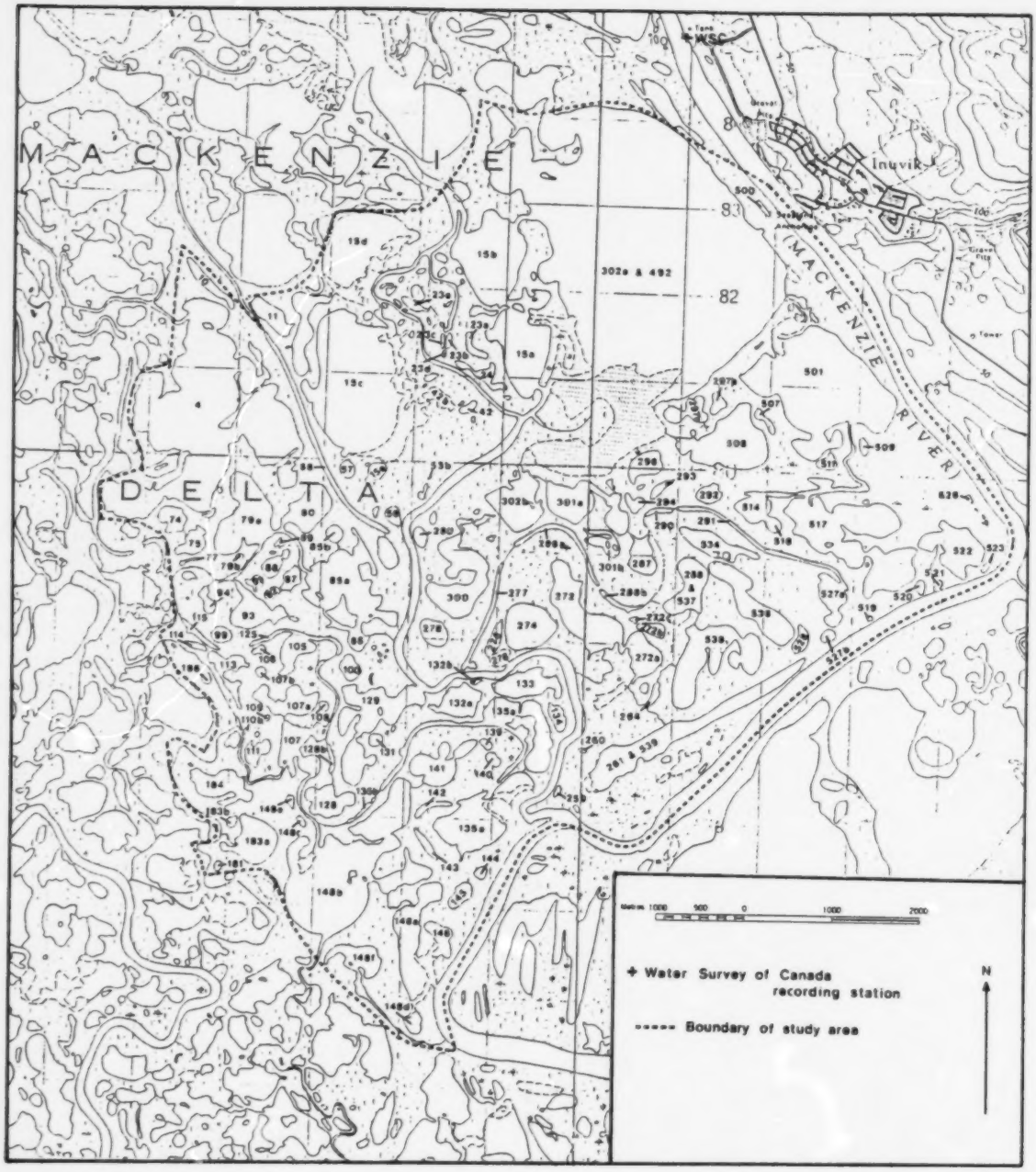

Observed vs Predicted Durations
>= 5m
probability F(t >= d)
duration (days)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
2
4
6
8
10
12
14
16
18
20


Observed vs Predicted Durations
>= 5.5m
probability F(t >= d)
duration (days)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
2
4
6
8
10
12
14
16
18
20


Observed vs Predicted Durations
>= 6m
probability F(t >= d)
duration (days)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
14
16
18
20

APPENDIX D: Lake Flooding

D1. Map of study lakes.


MACKENZIE
DELTA
MACKENZIE RIVER
Inuvik
WSC
82
83
1000 500 0 1000 2000
+ Water Survey of Canada recording station
----- Boundary of study area
N

D2. Lakes sorted by date of flooding (sill elevations).

MACKENZIE DELTA LAKES

(1) Original data: Lake data sorted by date of flooding.

Lake Name	Date and Julian day	Lake #	Lake area (km2)	Spring Sill (WSC+.127)	Summer Sill
Big L	May 18/86	302a + 492	8.530	1.5	0.150
	day 138	15 a	4.376	2.177	1.030
		15 b	0.418	2.177	1.030
		15 c	1.128	2.177	1.030
		86	0.058	2.177	1.030
	May 19	15 d	0.440	2.363	1.272
	139	4	3.305	2.363	1.272
Skidoo L		85	0.506	2.363	1.272
South L		129	0.378	2.363	1.272
	May 21	80	0.193	2.631	1.620
	141	79	0.346	2.631	1.620
		148 a	0.284	2.631	1.620
		302 b	0.189	2.631	1.620
		508	0.318	2.631	1.620
		501	1.269	2.631	1.620
	May 23	85 b	0.017	2.990	2.087
	143	93	0.169	2.990	2.087
		94	0.039	2.990	2.087
		107	0.167	2.990	2.087
		15 e	0.017	2.990	2.087
		300	0.344	2.990	2.087
		272	0.273	2.990	2.087
		301 a,b	0.366	2.990	2.087
		297 b	0.061	2.990	2.087
		296	0.070	2.990	2.087
		507	0.026	2.990	2.087
	May 25	42 b	0.034	3.389	2.606
	145	100	0.043	3.389	2.606
		58	0.137	3.389	2.606
		87	0.039	3.389	2.606
		107 a	0.107	3.389	2.606
		107 b	0.009	3.389	2.606
		148 b	0.948	3.389	2.606
		148 c	0.006	3.389	2.606
		141	0.172	3.389	2.606
		297 a	0.028	3.389	2.606
		511	0.016	3.389	2.606
		509	0.029	3.389	2.606
	May 26	57	0.023	3.671	2.972
	146	89	0.005	3.671	2.972
		79 b	0.005	3.671	2.972
		111	0.053	3.671	2.972
		184	0.177	3.671	2.972
		272 a	0.117	3.671	2.972
		272 b	0.021	3.671	2.972
		264	0.024	3.671	2.972
		500	0.011	3.671	2.972
	May 28	10	0.057	3.838	3.189
	148	11	1.054	3.838	3.189
		23 b	0.004	3.838	3.189
		42	0.022	3.838	3.189

		53	b	0.002	3.838	3.189
		88		0.054	3.838	3.189
		91		0.019	3.838	3.189
		75		0.078	3.838	3.189
		77		0.006	3.838	3.189
		105		0.100	3.838	3.189
		125		0.095	3.838	3.189
		106		0.010	3.838	3.189
		109		0.002	3.838	3.189
		110	b	0.002	3.838	3.189
		108		0.006	3.838	3.189
		148	d	0.034	3.838	3.189
		148	e	0.006	3.838	3.189
		146		0.100	3.838	3.189
		272	c	0.004	3.838	3.189
		538		0.379	3.838	3.189
		128	b	0.014	3.838	3.189
		280		0.024	3.838	3.189
	May 29	23	a	0.017	3.950	3.335
	149	23	c	0.004	3.950	3.335
		23	d	0.001	3.950	3.335
		23	e	0.021	3.950	3.335
		24		0.064	3.950	3.335
		74		0.071	3.950	3.335
		113		0.085	3.950	3.335
		537 + 288		0.180	3.950	3.335
		536		0.257	3.950	3.335
	May 30	287		0.098	4.077	3.500
	150	517		0.729	4.077	3.500
		148	f	0.124	4.077	3.500
NRC L		278		0.059	4.077	3.500
		514		0.109	4.077	3.500
		516		0.017	4.077	3.500
		131		0.012	4.077	3.500
		135	b	0.013	4.077	3.500
		92		0.016	4.077	3.500
	May 31	528		0.023	4.359	3.867
	151	128	a	0.126	4.359	3.867
		132	a	0.125	4.359	3.867
		132	b	0.002	4.359	3.867
		145		0.051	4.359	3.867
		294		0.028	4.359	3.867
	June 1	56		0.031	4.623	4.210
	152	139		0.010	4.623	4.210
		140		0.014	4.623	4.210
		133		0.013	4.623	4.210
		134		0.034	4.623	4.210
		261 + 539		0.485	4.623	4.210
		534		0.100	4.623	4.210
		293		0.025	4.623	4.210
		99		0.033	4.623	4.210
		114		0.009	4.623	4.210
		115		0.023	4.623	4.210
	June 2	274		0.212	4.768	4.398
	153	275		0.039	4.768	4.398
		276		0.005	4.768	4.398
	June 3	290		0.012	4.913	4.587
	154	183	a	0.236	4.913	4.587
		135		0.837	4.913	4.587
		259		0.006	4.913	4.587
		291		0.009	4.913	4.587

	520	0.002	4.913	4.587
	522	0.225	4.913	4.587
	523	0.007	4.913	4.587
June 5	142	0.029	5.169	4.920
156	277	0.054	5.169	4.920
	286 a	0.062	5.169	4.920
	286 b	0.027	5.169	4.920
	292	0.023	5.169	4.920
	527 a	0.085	5.169	4.920
	527 b	0.011	5.169	4.920
	519	0.005	5.169	4.920
	521	0.001	5.169	4.920
not flooded	186	0.010	5.169	4.920
on June 5	183 b	0.010	5.169	4.920
	181	0.008	5.169	4.920
	143	0.021	5.169	4.920
	144	0.015	5.169	4.920
	260	0.006	5.169	4.920
	526	0.001	5.169	4.920

* NOTE: 1) Spring sill elevations are based on mean daily WSC water levels, adjusted for slope (+ 0.127m) to the confluence of Big Lake Channel and Skidoo channels. (6.35km. * .00002 = .127m).

The mean of WSC daily levels was used, for each day from the last daily observation up to and including the next day of observation.

2) Summer sill = 1.3 * spring sill - 1.8m.

D3. Lakes sorted by lake number.

(2) Lake data sorted by lake number.

Lake Name	Lake #	Lake area (km2)	Spring Sill (WSC+.127)	Summer Sill
	4	3.305	2.363	1.272
	10	0.057	3.838	3.189
	11	1.054	3.838	3.189
	15 a	4.376	2.177	1.030
	15 b	0.418	2.177	1.030
	15 c	1.128	2.177	1.030
	15 d	0.440	2.363	1.272
	15 e	0.017	2.990	2.087
	23 a	0.017	3.950	3.335
	23 b	0.004	3.838	3.189
	23 c	0.004	3.950	3.335
	23 d	0.001	3.950	3.335
	23 e	0.021	3.950	3.335
	24	0.064	3.950	3.335
	42	0.022	3.838	3.189
	42 b	0.034	3.389	2.606
	53 b	0.002	3.838	3.189
	56	0.031	4.623	4.210
	57	0.023	3.671	2.972
	58	0.137	3.389	2.606
	74	0.071	3.950	3.335
	75	0.078	3.838	3.189
	77	0.006	3.838	3.189
	79	0.346	2.631	1.620
	79 b	0.005	3.671	2.972
	80	0.193	2.631	1.620
Skidoo L	85	0.506	2.363	1.272
	85 b	0.017	2.990	2.087
	86	0.058	2.177	1.030
	87	0.039	3.389	2.606
	88	0.054	3.838	3.189
	89	0.005	3.671	2.972
	91	0.019	3.838	3.189
	92	0.016	4.077	3.500
	93	0.169	2.990	2.087
	94	0.039	2.990	2.087
	99	0.033	4.623	4.210
	100	0.043	3.389	2.606
	105	0.100	3.838	3.189
	106	0.010	3.838	3.189
	107	0.167	2.990	2.087
	107 a	0.107	3.389	2.606
	107 b	0.009	3.389	2.606
	108	0.006	3.838	3.189
	109	0.002	3.838	3.189
	110 b	0.002	3.838	3.189
	111	0.053	3.671	2.972
	113	0.085	3.950	3.335
	114	0.009	4.623	4.210
	115	0.023	4.623	4.210
	125	0.095	3.838	3.189
	128 a	0.126	4.359	3.867
	128 b	0.014	3.838	3.189
South L	129	0.378	2.363	1.272
	131	0.012	4.077	3.500
	132 a	0.125	4.359	3.867
	132 b	0.002	4.359	3.867
	133	0.013	4.623	4.210
	134	0.034	4.623	4.210
	135	0.837	4.913	4.587
	135 b	0.013	4.077	3.500
	139	0.010	4.623	4.210

	140		0.014	4.623	4.210
	141		0.172	3.389	2.606
	142		0.029	5.169	4.920
	143		0.021	5.169	4.920
	144		0.015	5.169	4.920
	145		0.051	4.359	3.867
	146		0.100	3.838	3.189
	148	a	0.284	2.631	1.620
	148	b	0.948	3.389	2.606
	148	c	0.006	3.389	2.606
	148	d	0.034	3.838	3.189
	148	e	0.006	3.838	3.189
	148	f	0.124	4.077	3.500
	181		0.008	5.169	4.920
	183	a	0.236	4.913	4.587
	183	b	0.010	5.169	4.920
	184		0.177	3.671	2.972
	186		0.010	5.169	4.920
	259		0.006	4.913	4.587
	260		0.006	5.169	4.920
	261		0.485	4.623	4.210
	264		0.024	3.671	2.972
	272		0.273	2.990	2.087
	272	a	0.117	3.671	2.972
	272	b	0.021	3.671	2.972
	272	c	0.004	3.838	3.189
	274		0.212	4.768	4.398
	275		0.039	4.768	4.398
	276		0.005	4.768	4.398
	277		0.054	5.169	4.920
NRC L	278		0.059	4.077	3.500
	280		0.024	3.838	3.189
	286	a	0.062	5.169	4.920
	286	b	0.027	5.169	4.920
	287		0.098	4.077	3.500
	290		0.012	4.913	4.587
	291		0.009	4.913	4.587
	292		0.023	5.169	4.920
	293		0.025	4.623	4.210
	294		0.028	4.359	3.867
	296		0.070	2.990	2.087
	297	a	0.028	3.389	2.606
	297	b	0.061	2.990	2.087
	300		0.344	2.990	2.087
	301	a	0.366	2.990	2.087
Big L	302	a	8.530	1.5	0.150
	302	b	0.189	2.631	1.620
	500		0.011	3.671	2.972
	501		1.269	2.631	1.620
	507		0.026	2.990	2.087
	508		0.318	2.631	1.620
	509		0.029	3.389	2.606
	511		0.016	3.389	2.606
	514		0.109	4.077	3.500
	516		0.017	4.077	3.500
	517		0.729	4.077	3.500
	519		0.005	5.169	4.920
	520		0.002	4.913	4.587
	521		0.001	5.169	4.920
	522		0.225	4.913	4.587
	523		0.007	4.913	4.587
	526		0.001	5.169	4.920

527 a	0.085	5.169	4.920
527 b	0.011	5.169	4.920
528	0.023	4.359	3.867
534	0.100	4.623	4.210
536	0.257	3.950	3.335
537	0.180	3.950	3.335
538	0.379	3.838	3.189

* NOTE: 1) Spring sill elevations are based on mean daily WSC water levels, adjusted for slope (+ 0.127m) to the confluence of Big Lake Channel and Skidoo channels. (6.35km. * .00002 = .127m).

The mean of WSC daily levels was used, for each day from the last daily observation up to and including the next day of observation.

2) Summer sill = 1.3 * spring sill - 1.8m.

D4. Lakes sorted by lake area.

(3) Lake data sorted by lake area.

Lake Name	Lake #	Lake area (km2)	Spring Sill (WSC+.127)	Summer Sill
Big L	302 a	8.530	1.5	0.150
	15 a	4.376	2.177	1.030
	4	3.305	2.363	1.272
	501	1.269	2.631	1.620
	15 c	1.128	2.177	1.030
	11	1.054	3.838	3.189
	148 b	0.948	3.389	2.606
	135	0.837	4.913	4.587
	517	0.729	4.077	3.500
Skidoo L	85	0.506	2.363	1.272
	261	0.485	4.623	4.210
	15 d	0.440	2.363	1.272
	15 b	0.418	2.177	1.030
	538	0.379	3.838	3.189
South L	129	0.378	2.363	1.272
	301 a	0.366	2.990	2.087
	79	0.346	2.631	1.620
	300	0.344	2.990	2.087
	508	0.318	2.631	1.620
	148 a	0.284	2.631	1.620
	272	0.273	2.990	2.087
	536	0.257	3.950	3.335
	183 a	0.236	4.913	4.587
	522	0.225	4.913	4.587
	274	0.212	4.768	4.398
	80	0.193	2.631	1.620
	302 b	0.189	2.631	1.620
	537	0.180	3.950	3.335
	184	0.177	3.671	2.972
	141	0.172	3.389	2.606
	93	0.169	2.990	2.087
	107	0.167	2.990	2.087
	58	0.137	3.389	2.606
	128 a	0.126	4.359	3.867
	132 a	0.125	4.359	3.867
	148 f	0.124	4.077	3.500
	272 a	0.117	3.671	2.972
	514	0.109	4.077	3.500
	107 a	0.107	3.389	2.606
	534	0.100	4.623	4.210
	146	0.100	3.838	3.189
	105	0.100	3.838	3.189
	287	0.098	4.077	3.500
	125	0.095	3.838	3.189
	527 a	0.085	5.169	4.920
	113	0.085	3.950	3.335
	75	0.078	3.838	3.189
	74	0.071	3.950	3.335
	296	0.070	2.990	2.087
	24	0.064	3.950	3.335
	286 a	0.062	5.169	4.920
	297 b	0.061	2.990	2.087
NRC L	278	0.059	4.077	3.500
	86	0.058	2.177	1.030
	10	0.057	3.838	3.189
	277	0.054	5.169	4.920
	88	0.054	3.838	3.189
	111	0.053	3.671	2.972
	145	0.051	4.359	3.867
	100	0.043	3.389	2.606
	94	0.039	2.990	2.087
	275	0.039	4.768	4.398

87		0.039	3.389	2.606
42	b	0.034	3.389	2.606
148	d	0.034	3.838	3.189
134		0.034	4.623	4.210
99		0.033	4.623	4.210
56		0.031	4.623	4.210
509		0.029	3.389	2.606
142		0.029	5.169	4.920
294		0.028	4.359	3.867
297	a	0.028	3.389	2.606
286	b	0.027	5.169	4.920
507		0.026	2.990	2.087
293		0.025	4.623	4.210
264		0.024	3.671	2.972
280		0.024	3.838	3.189
528		0.023	4.359	3.867
57		0.023	3.671	2.972
115		0.023	4.623	4.210
292		0.023	5.169	4.920
42		0.022	3.838	3.189
143		0.021	5.169	4.920
272	b	0.021	3.671	2.972
23	e	0.021	3.950	3.335
91		0.019	3.838	3.189
15	e	0.017	2.990	2.087
23	a	0.017	3.950	3.335
516		0.017	4.077	3.500
85	b	0.017	2.990	2.087
92		0.016	4.077	3.500
511		0.016	3.389	2.606
144		0.015	5.169	4.920
140		0.014	4.623	4.210
128	b	0.014	3.838	3.189
135	b	0.013	4.077	3.500
133		0.013	4.623	4.210
290		0.012	4.913	4.587
131		0.012	4.077	3.500
527	b	0.011	5.169	4.920
500		0.011	3.671	2.972
183	b	0.010	5.169	4.920
106		0.010	3.838	3.189
186		0.010	5.169	4.920
139		0.010	4.623	4.210
107	b	0.009	3.389	2.606
114		0.009	4.623	4.210
291		0.009	4.913	4.587
181		0.008	5.169	4.920
523		0.007	4.913	4.587
260		0.006	5.169	4.920
148	c	0.006	3.389	2.606
148	e	0.006	3.838	3.189
259		0.006	4.913	4.587
108		0.006	3.838	3.189
77		0.006	3.838	3.189
519		0.005	5.169	4.920
276		0.005	4.768	4.398
79	b	0.005	3.671	2.972
89		0.005	3.671	2.972
23	b	0.004	3.838	3.189
272	c	0.004	3.838	3.189
23	c	0.004	3.950	3.335
110	b	0.002	3.838	3.189

132 b	0.002	4.359	3.867
53 b	0.002	3.838	3.189
520	0.002	4.913	4.587
109	0.002	3.838	3.189
526	0.001	5.169	4.920
521	0.001	5.169	4.920
23 d	0.001	3.950	3.335

* NOTE: 1) Spring sill elevations are based on mean daily WSC water levels, adjusted for slope (+ 0.127m) to the confluence of Big Lake Channel and Skidoo channels. (6.35km. * .00002 = .127m).

The mean of WSC daily levels was used, for each day from the last daily observation up to and including the next day of observation.

2) Summer sill = 1.3 * spring sill - 1.8m.

D5. Summary of spring and summer lake sill elevations.

Spring sills - grouped data

Elevation (m asl)	Group	Number of lakes: # of lakes	% of lakes	Cumulative % less	Cumulative % greater	Lake area: Lake area (km2)	% of area	Cumulative % less	Cumulative % greater
1.0				0	100.0			0	100.0
1.5	1.25-1.74	2	1.5	1.5	98.5	8.53	26.4	26.4	73.6
2.0	1.75-2.24	4	3.0	4.5	95.5	5.98	18.5	44.9	55.1
2.5	2.24-2.74	10	7.6	12.1	87.9	7.228	22.4	67.2	32.7
3.0	2.75-3.24	11	8.3	20.4	79.5	1.549	4.8	72.0	28.0
3.5	3.25-3.74	21	15.9	36.3	63.6	2.004	6.2	78.2	21.8
4.0	3.75-4.24	40	30.3	66.7	33.3	3.949	12.2	90.4	9.5
4.5	4.25-4.74	17	12.9	79.5	20.5	1.132	3.5	93.9	6.0
5.0	4.75-5.24	20	15.2	94.7	5.3	1.887	5.8	99.8	0.2
5.5	5.24-	7	5.3	100.0	0.0	0.071	0.2	100.0	0

Mean spring sill elevation = 3.92 m asl
St. dev. = 0.90 m asl

Summer sills - grouped data

Elevation (m asl)	Group	Number of lakes: # of lakes	% of lakes	Cumulative % less	Cumulative % greater	Lake area: Lake area (km2)	% of area	Cumulative % less	Cumulative % greater
				0	100.0			0	100.0
0.0	-0.25-.24	2	1.5	1.5	98.5	8.53	26.4	26.4	73.6
0.5	0.25-0.74	0	0.0	1.5	98.5	0	0.0	26.4	73.6
1.0	0.75-1.24	4	3.0	4.5	95.5	5.98	18.5	44.9	55.1
1.5	1.25-1.74	10	7.6	12.1	87.9	7.228	22.4	67.3	32.8
2.0	1.75-2.24	11	8.3	20.5	79.5	1.549	4.8	72.0	28.0
2.5	2.24-2.74	12	9.1	29.5	70.5	1.568	4.8	76.9	23.1
3.0	2.75-3.24	31	23.5	53.0	47.0	2.508	7.8	84.7	15.4
3.5	3.25-3.74	18	13.6	66.7	33.3	1.877	5.8	90.5	9.6
4.0	3.75-4.24	17	12.9	79.5	20.5	1.132	3.5	94.0	6.1
4.5	4.25-4.74	11	8.3	87.9	12.1	1.59	4.9	98.9	1.1
5.0	4.75-5.24	9	6.8	94.7	5.3	0.297	0.9	99.8	0.2
5.5	5.24-	7	5.3	100.0	0.0	0.071	0.2	100.0	0

Mean summer sill elevation = 3.24 m asl
St. dev. = 1.20 m asl